

This is a scanned version of the text of the original Soil Survey report of Yakima Indian Reservation Irrigated Area, Washington, Part of Yakima County issued January 1976. Original tables and maps were deleted. There may be references in the text that refer to a table that is not in this document.

Updated tables were generated from the NRCS National Soil Information System (NASIS). The soil map data has been digitized and may include some updated information. These are available from <http://soildatamart.nrcs.usda.gov>.

Please contact the State Soil Scientist, Natural Resources Conservation Service (formerly Soil Conservation Service) for additional information.

SOIL SURVEY OF YAKIMA INDIAN RESERVATION IRRIGATED AREA, WASHINGTON, PART OF YAKIMA COUNTY

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, AND UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF INDIAN AFFAIRS, IN COOPERATION WITH WASHINGTON STATE AGRICULTURAL EXPERIMENT STATION.

THE YAKIMA INDIAN RESERVATION IRRIGATED AREA is in Yakima County, in the south-central part of the State of Washington (fig. 1).

The survey area consists of the valleys west and south of the Yakima River and along Toppenish Creek and its tributaries and the southern half of the Ahtanum Valley. It is roughly triangular in shape. The town of Mabton is at the lower southeast point of the triangle, Union Gap is at the apex on the north, and White Swan is at the western point of the triangle. The survey area is about 222,930 acres, or about 348 square miles. About 190,000 acres is irrigated. Parts not irrigated are idle or are used mainly for grazing or as wildlife habitat.

The survey area includes both Indian Tribal lands and privately owned, or deeded, land. The offices of the Yakima Indian Agency are located in Toppenish.

The soils of the survey area are dominantly nearly level or gently sloping. They formed mainly in alluvium, loess, lake sediments, or eolian sand, or in material weathered from basalt, or in combinations of these materials. They range from sand to clay. Many have impeded drainage, and some are affected by excessive amounts of salts or alkali, or both.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Yakima Indian Reservation Irrigated Area, where they are located, and how they can be used. The soil scientists went into the survey area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform pro-

Soils that have profiles almost alike make up a soil series (4). Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Generally a soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Naches and Toppenish, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Naches loam, 0 to 2 percent slopes, is one of two phases within the Naches series.

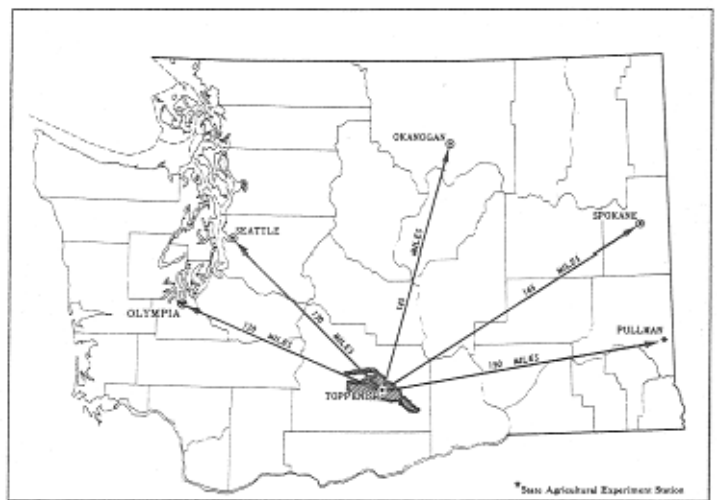


Figure 1.-Location of the Yakima Indian Reservation Irrigated Area in Washington.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it can contain small areas of other soils that are too small to delineate.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing medium for native and cultivated plants, and when used as material, foundations, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Yakima Indian Reservation Irrigated Area. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed or a wildlife area or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The seven soil associations in the Yakima Indian Reservation Irrigated Area are described on the following pages.

1. Quincy-Hezel association

Deep, somewhat excessively drained, coarse-textured soils formed in windblown sand that in places is underlain by lake sediments

This association is on gently sloping to moderately sloping, hummocky or dunelike, rolling terraces. The soils are somewhat excessively drained and coarse textured. They formed in deep windblown sand or in a mantle of windblown sand over medium-textured lake sediments. The vegetation is mainly cheatgrass, needleandthread, and big sagebrush. Elevations range from 650 to 800 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 3 percent of the survey area. It is about 50 percent Quincy soils, 40 percent Hezel soils, and 10 percent Esquatzel and Warden soils.

Hezel soils are grayish-brown loamy fine sand 15 to 35 deep thick over light brownish-gray, calcareous, stratified silt loam. Quincy soils are grayish-brown loamy sand and loamy fine sand more than 40 inches deep.

Soil blowing is a constant concern. Even in irrigated areas the hazard of soil blowing is severe if the soil is bare of vegetation.

About 50 percent of this association is irrigated by water diverted from the Yakima River. Sprinkler irrigation is the most satisfactory, but a few areas are surface irrigated. Hay and pasture are well suited. A few areas are used for irrigated row crops, including asparagus, corn, peas, potatoes, and sugar beets.

This association is very sparsely populated. About 50 percent is Indian Tribal Land, and 50 percent is privately owned. The average farm is about 200 acres in size. Most farm boundaries overlap into the more stable and productive soils.

2. Ashue-Naches association

Deep, well-drained, medium-textured soils formed in old alluvium and underlain by very gravelly material

This association is on a nearly level or gently sloping, old alluvial plain. The soils are well drained and medium textured. They formed in old alluvium. The vegetation in nonirrigated areas is big sagebrush, rabbitbrush, and bunchgrasses. Elevations range from 650 to 950 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 22 percent of the survey area. It is about 50 percent Ashue soils, 40 percent Naches soils, and about 10 percent Esquatzel, Toppenish, Track, Umapine, Warden, and Weirman soils.

Ashue soils have a surface layer of brown loam or gravelly loam over a very gravelly sandy clay loam subsoil. The upper part of the substratum is very gravelly sandy loam. The lower part, below a depth of about 36 inches, is very gravelly sand.

Naches soils have a surface layer of brown loam over a sandy clay loam subsoil. The substratum is stratified loam and fine sandy loam over very gravelly sand at a depth of about 38 inches.

Most of this association is surface irrigated or sprinkler irrigated. Irrigation water is diverted from the Yakima River.

Among the crops grown on this association are corn, grapes, hops, mint, sugar beets, tree fruits, and truck crops (fig. 2), and grasses and legumes for hay and pasture. The association also provides habitat for wildlife, mainly Chinese pheasants and quail.

About 40 percent of this association is Indian Tribal Land, and 60 percent is privately owned. The average farm is about



Figure 2.-Double cropping in one season on Naches loam. Top: Rows are irrigated in August after harvest of sweet corn. Bottom: Lettuce is harvested in October.

80 acres in size. Most farmers reside on their farms, which makes areas of this association the most populated in the rural parts of the survey area.

3. Logy-Simcoe association

Deep and moderately deep, well-drained, medium-textured soils formed in alluvium and windlain material and underlain by very gravelly material or basalt

This association is on gently sloping uplands and nearly level bottom land dissected by intermittent stream channels in many places. The soils are deep and moderately deep, well drained, and medium textured. They formed in windlaid material and alluvium underlain by very gravelly material or basalt bedrock. The vegetation is mainly big sagebrush, bluegrass, bunchgrass, and cheatgrass. Elevations range from 700 to 1,400 feet. The mean annual precipitation is 6 to 12 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 120 to 170 days.

This association makes up about 5 percent of the survey area. It is about 30 percent Logy soils, 15 percent Simcoe soils, 15 percent Onyx soils, 10 percent Yakima soils, and about 30 percent Ahtanum, Esquatzel, Rock Creek, Shano, Toppenish, and Wahtum soils.

Logy soils have a surface layer of dark grayish-brown silt loam or cobbly silt loam and are very gravelly below a depth of about 19 inches. Simcoe soils have a surface layer of grayish-brown silt loam and a subsoil of heavy silt loam and silty clay loam and are about 37 inches deep over basalt. Onyx soils are silt loam alluvial soils more than 60 inches deep.

About 20 percent of this association is irrigated. Irrigation water is diverted mainly from Toppenish and Medicine Creeks and other creeks. Among crops grown on this association are corn and small grain and grasses and legumes for hay and pasture. Among the wildlife species are quail and pheasants.

Except for the immediate vicinity of White Swan this association is sparsely populated. About 70 percent of the area is Indian Tribal Land, and 30 percent is deeded land.

4. Toppenish-Umapine association

Deep, somewhat poorly drained, medium textured and moderately fine textured soils formed in alluvium

This association is on nearly level and gently sloping, alluvial plains dissected by intermittent and perennial streams. The soils are somewhat poorly drained and medium textured and moderately fine textured. They formed in alluvial deposits. The vegetation is mainly big sagebrush, black greasewood, rabbitbrush, inland saltgrass, water-tolerant grasses, and sedges. Cottonwood and willow trees grow along perennial streams. Elevations range from 650 to 900 feet. The mean annual precipitation is 6 to 9 inches, mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 30 percent of the survey area. It is about 40 percent Toppenish soils, 20 percent Umapine soils, 15 percent Kittitas soils, and about 25 percent Ahtanum, Esquatzel, Fiander, Naches, Onyx, Stanfield, Track, and Yost soils.

Toppenish soils have a surface layer of dark-gray silt loam or silty clay loam. The subsoil extends to a depth of 46 inches. It is stratified, dark-gray, light brownish-gray, and grayishbrown silt loam, clay loam, and gravelly clay loam and is

prominently mottled. It is underlain by very gravelly sandy loam.

Umapine soils are light brownish-gray, grayish-brown, and light-gray silt loams more than 60 inches deep. They are saline and very strongly alkaline in the upper 30 inches, and they are moderately alkaline or mildly alkaline below this depth.

Kittitas soils have a surface layer of gray, very dark gray, and dark grayish-brown silt loam or silty clay loam. This layer is underlain by weakly stratified silt loam that extends to a depth of more than 60 inches. The soils are generally saline and very strongly alkaline in the upper 10 to 24 inches.

About 80 percent of this association is surface irrigated or sprinkler irrigated. The rest is severely limited by a high water table. Some poorly drained areas are subirrigated or flood irrigated. Irrigation water is diverted mainly from the Yakima River and in lesser amounts from Toppenish and Satus Creeks. In the area north of the Ahtanum Ridge, it is diverted from Ahtanum Creek.

Among the crops grown on this association are asparagus, grasses and legumes for hay and pasture, hops, mint, sugar beets, and small grain. The association also provides habitat for wildlife, mainly ducks, geese, pheasants, and quail.

About 45 percent of this association is Indian Tribal Land, and 55 percent is deeded land. The average farm is about 120 acres in size. Most farmers reside on their farms, and many have facilities for farm laborers.

5. White Swan association

Deep, well-drained, medium textured and moderately coarse textured soils formed in windblown deposits underlain by lake sediments

This association consists of well-drained, medium textured and moderately coarse textured soils. These soils formed in a thin mantle of wind-laid deposits over lake sediments. The vegetation is black greasewood, big sagebrush, inland saltgrass, and bunchgrass. Elevations range from 800 to 1,050 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 3 percent of the survey area. It is about 80 percent White Swan soils, 15 percent Warden soils, and 5 percent Ahtanum, Esquatzel, Kittitas, and Stanfield soils.

White Swan soils have a surface layer of grayish-brown silt loam. The subsoil is moderately or strongly alkaline, grayish-brown or pale-brown silty clay loam. The substratum is light grayish-brown, calcareous, weakly stratified silt loam.

Warden soils have a surface layer of grayish-brown silt loam or fine sandy loam. The subsoil is grayish-brown silt loam. The substratum is light brownish-gray, calcareous, weakly stratified silt loam.

About 20 percent of this association is irrigated. Irrigation water is diverted from creeks and the Yakima River. Both surface and sprinkler irrigation is used. Among the crops grown on this association are grasses and legumes for hay and pasture, small grain, and sugar beets. Among the wildlife species are quail, doves, and pheasants.

This association is sparsely developed and populated. About 75 percent is Indian Tribal Land, and 25 percent is privately owned. The average farm is about 80 acres in size. If irrigation farming of White Swan soils is to be successful, the strongly alkaline subsoil must be considered. The soils

can be deep plowed, leached, and adequately drained. Soil amendments, for example, gypsum, are needed.

6. Warden-Shano association

Deep, well-drained, medium textured and moderately coarse textured soils formed in windlain deposits underlain by lake sediment, or in deep windlain deposits

This association is mainly on nearly level and gently sloping uplands. A few areas along the pronounced drainageways are steep. The soils are well drained and medium textured and moderately coarse textured. They formed in windlain deposits and the underlying lake sediment or in silty windlain deposits. The vegetation is mainly bunchgrasses and big sagebrush. Elevations range from 600 to 1,300 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 29 percent of the survey area. It is about 60 percent Warden soils, 20 percent Shano soils, and 20 percent Esquatzel, Hezel, and Ritzville soils.

Warden soils have a surface layer of grayish-brown silt loam or fine sandy loam. The subsoil is grayish-brown silt loam. The substratum is weakly stratified and calcareous, light brownish-gray silt loam. Shano soils are brown, grayish-brown, and pale-brown silt loam to a depth of 40 to more than 60 inches.

Most of this association is irrigated. Irrigation water is diverted mainly from the Yakima River, but in the area north of the Ahtanum Ridge it is diverted from Ahtanum Creek. The soils are well suited to surface or sprinkler irrigation. The type of irrigation used depends on the crop to be grown and the topography.

Among the crops grown on this association are asparagus, corn, grasses and legumes for hay and pasture, hops, mint, tree fruits, potatoes, sugar beets, and grapes. The association also provides habitat for wildlife, mainly Chinese pheasants, quail, and doves.

About 50 percent of the area is Indian Tribal Land, and the rest is privately owned. The average farm is about 160 acres in size. Most farmers reside on their farms, and many have facilities for farm laborers.

7. Weirman association

Deep, somewhat excessively drained and well drained, medium textured and moderately coarse textured soils formed in recent or old alluvium and underlain by very gravelly material

This association is on the nearly level to gently sloping alluvial plain adjacent to the Yakima River. It is dissected in places by old flood channels and tributaries to the river. The soils are somewhat excessively drained and well drained and medium textured to moderately coarse textured. They formed in alluvium. The vegetation is big sagebrush, bunchgrass, black greasewood, and inland saltgrass. Cottonwood and willow trees grow along the stream channels. Elevations range from 650 to 950 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days.

This association makes up about 8 percent of the survey area. It is about 65 percent Weirman soils, 10 percent Ashue soils, and about 25 percent Esquatzel, Fiander, Toppenish, Track, Umapine, and Zillah soils.

Weirman soils are stratified. The surface layer is grayish-brown silt loam, sandy loam, gravelly sandy loam, and fine

sandy loam grading to a very gravelly loamy sand at a depth of about 20 inches.

Ashue soils have a surface layer of brown loam or gravelly loam. The subsoil is very gravelly sandy clay loam. The upper part of the substratum is very gravelly sandy loam. The lower part is very gravelly sand below a depth of about 36 inches.

About 70 percent of this association is irrigated. Irrigation water is diverted from the Yakima River. The soils are well suited to sprinkler irrigation or to short runs of surface irrigation.

Among the crops grown on this association are asparagus, corn, grapes, grasses and legumes for hay and pasture, tree fruits, and truck crops. The association also provides habitat for wildlife, mainly pheasants, quail, doves, and ducks.

About 70 percent of this association is Indian Tribal Land, and 30 percent is privately owned. The average farm is about 80 acres in size. In the vicinity of Wapato many of the smaller tracts are planted to truck crops.

Descriptions of the Soils

This section describes the soil series and mapping units in the Yakima Indian Reservation Irrigated Area. Each soil series is described in detail, and then, briefly, each mapping unit in that series is described. Unless specifically mentioned otherwise, it is to be assumed that what is stated about the soil series applies to all the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile; that is, the sequence of layers from the surface downward to rock or other underlying material. The first description of this profile, under the series heading, is brief and in terms familiar to the layman. The second, in the description of the first mapping unit in the series, is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for dry soil unless otherwise stated. The profile described is representative of all mapping units in that series. If the profile of a given mapping unit differs from the one described for the series, these differences are stated in describing the mapping unit.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page for the description of each capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey. More detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (4).

Ahtanum Series

The Ahtanum series consists of somewhat poorly drained, saline-alkali soils that are moderately deep over a lime-silica

In the original manuscript, there was a table in this space.
All tables have been updated and are available at <http://soildatamart.nrcs.usda.gov>.

cemented hardpan. These soils formed in mixed old alluvium. They are on low old alluvial plains. Slopes are mostly less than 1 percent, but a few short slopes are as much as 5 percent. The native vegetation is principally black greasewood, inland saltgrass, and basin wildrye. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Kittitas, Toppenish, and Wahtum soils.

In a representative profile, the surface layer is grayish-brown, very strongly alkaline silt loam about 10 inches thick. The substratum is light brownish-gray silt loam to a depth of 21 inches. Below this is a pale-brown, lime-silica cemented hardpan about 10 inches thick. Below the pan, the substratum is pale-brown silt loam to a depth of 50 inches and very pale brown loamy sand to a depth of 60 inches.

Some areas of Ahtanum soils have been drained and are irrigated.

Ahtanum silt loam, 0 to 2 percent slopes (AhA). This soil is in low areas parallel to Toppenish and Ahtanum Creeks or their tributaries. In most places the slope is less than 1 percent. A representative profile is one-fourth mile

south of Branch Road and 1 mile west of Brownstown, SE1/4NE1/4 sec. 36, T. 11, R. 17 E., W.M.

Ap1-0 to 4 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, thin, platy structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; violent effervescence; very strongly alkaline; abrupt, smooth boundary.

Ap2-4 to 10 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, medium, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; violent effervescence; very strongly alkaline; clear, wavy boundary.

C1-10 to 21 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common roots; many fine pores; violent effervescence; strongly alkaline; gradual, wavy boundary.

C2casim-21 to 31 inches, pale-brown (10YR 6/3) lime-silica cemented hardpan, dark brown (10YR 4/3) moist; massive; very hard, very firm, slightly sticky and slightly plastic; few roots in cracks; many fine pores; violent effervescence; moderately alkaline; abrupt, wavy boundary.

C3-31 to 50 inches, pale-brown (10YR 6/3) silt loam, dark brown

(10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; many fine pores; moderately alkaline; abrupt, smooth boundary.

IIC4-50 to 60 inches, very pale brown (10YR 7/3) loamy sand, yellowish brown (10YR 5/4) moist; single grained; loose; mildly alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It ranges from 6 to 18 inches in thickness. It is typically very strongly alkaline, but in some drained and irrigated areas it is moderately alkaline. The C2casim horizon, or hardpan, ranges from 1 inch to more than 12 inches in thickness. In some large areas it has been broken and is not continuous. Depth to the C2casim horizon ranges from 20 to 40 inches.

Included with this soil in mapping are small areas of Kittitas, Stanfield, and Toppenish soils; areas of poorly drained soils; and a few areas where the hardpan is above a depth of 20 inches.

The seasonal high water table is at a depth of 1 to 2 feet. In cultivated areas the water table has been lowered by deep drains to a depth of 3 to more than 5 feet. Permeability is moderate above the hardpan and very slow within the pan. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds about 5 to 9 inches of water that plants can use. Capability unit IIw-1 irrigated.

Ahtanum silt loam, 2 to 5 percent slopes (AhB). Except for slope, this soil is similar to Ahtanum silt loam, 0 to 2 percent slopes. Included in mapping are some poorly drained areas that receive excess seepage from more elevated areas. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIw-1 irrigated.

Ashue Series

The Ashue series consists of well-drained soils that formed in old alluvium. These soils are on old alluvial plains, mostly in the vicinity of the city of Wapato. Slopes are 0 to 5 percent. The native vegetation is mainly cheatgrass, big sagebrush, and rabbitbrush. Elevations range from 700 to 900 feet. The

mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost free season is 130 to 180 days. These soils are associated with Naches, Toppenish, Track, and Weirman soils.

In a representative profile, the surface layer is brown loam about 10 inches thick. The subsoil is dark-brown very gravelly sandy clay loam about 10 inches thick. The substratum is dark yellowish-brown very gravelly sandy loam to a depth of 36 inches and dark grayish-brown very gravelly sand to a depth of 62 inches. The soil is neutral or mildly alkaline.

Most of the acreage of Ashue soils is irrigated (fig. 3).

Ashue loam, 0 to 2 percent slopes (AsA). Many areas of this soil that were previously gently sloping and undulating have been leveled. In most areas, the slope is about 1 percent. A representative profile is 200 feet north of Branch Road and 1,000 feet west of Lateral B Road, SE1/4SE1/4 sec. 25, T. 11 N., R. 18 E., W.M.

Ap1-0 to 4 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; weak, fine, granular structure; hard, friable, slightly sticky and slightly plastic; many roots; neutral; abrupt, smooth boundary.

Ap2-4 to 10 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; massive tillage pan; very hard, friable, slightly sticky and slightly plastic; common fine roots; many fine tubular pores; neutral; gradual, wavy boundary.

B2t-10 to 20 inches, dark-brown (7.5YR 4/4) very gravelly sandy clay loam, dark yellowish brown (10YR 3/4) moist; weak blocky structure; hard, firm, sticky and plastic; common fine roots; few fine tubular pores; 10 percent gravel and cobbles; neutral; gradual, wavy boundary.

C1-20 to 36 inches, dark yellowish-brown (10YR 4/4) very gravelly sandy loam, dark yellowish brown (10YR 3/4) moist; massive; hard, friable, nonsticky and slightly plastic; common -me roots; 80 percent gravel and cobbles; mildly alkaline; abrupt, wavy boundary.

IIC2-36 to 62 inches, dark grayish-brown (10YR 4/2) very gravelly sand, very dark grayish brown (10YR 3/2) moist; single grained; loose, nonsticky and nonplastic; few roots; mildly alkaline.



Figure 3.—Irrigated young orchard on Ashue gravelly loam. A solid set, overhead sprinkler is used for irrigation.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. It is loam or silt loam. The B2t horizon is very gravelly loam or sandy clay loam. The C1 horizon is very gravelly loam or sandy loam.

Included with this soil in mapping are small very gravelly areas and areas that have been leveled or smoothed and have some gravel and cobbles mixed with the surface layer. Also included are a few small saline-alkali areas and small areas of Naches, Toppenish, Track, Weirman, and Zillah soils.

This soil is well drained. Permeability is moderately slow in the subsoil and the upper part of the substratum and very rapid in the lower part of the substratum. Runoff is slow, and the hazard of erosion is slight. The soil holds 4 to 6 inches of water that plants can use. Capability unit IIIs-1 irrigated.

Ashue loam, 2 to 5 percent slopes (AsB).-Except for slope, this soil is similar to Ashue loam, 0 to 2 percent slopes. It is gently undulating and is incised in places by streambeds. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIVe-1 irrigated.

Ashue gravelly loam, 0 to 2 percent slopes (AuA).This soil is similar to Ashue loam, 0 to 2 percent slopes, but the surface layer is gravelly and in a few areas is cobbly. Runoff is slow, and the hazard of erosion is slight. Capability unit IVs-2 irrigated.

Ashue gravelly loam, 2 to 5 percent slopes (AuB).Except for slope and a gravelly surface layer, this soil is similar to Ashue loam, 0 to 2 percent slopes. It is undulating and is incised in places by streambeds. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIVe-1 irrigated.

Esquatzel Series

The Esquatzel series consists of deep, nearly level to gently sloping, well-drained soils that formed in alluvium. These soils are on bottom land incised by perennial or intermittent streams. The native vegetation is principally big sagebrush, rabbitbrush, and bunchgrass. Elevations range from 650 to 850 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Ritzville, Shano, Umapine, and Warden soils.

In a representative profile, the surface layer is brown silt loam about 9 inches thick. The substratum is brown silt loam to a depth of 15 inches and stratified, pale-brown silt loam to a depth of 64 inches.

Most of the acreage of Esquatzel soils is irrigated and cropped.

Esquatzel silt loam, 0 to 2 percent slopes (EtA).-In most places this soil has slopes of about 1 percent. A representative profile is approximately 200 feet north of Pierre Road and one-half mile west of Pasco Road, SW1/4SE1/4 sec. 1, T. 8 N., R. 21 E., W.M.

Ap1-0 to 4 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, medium, granular structure; soft, friable, slightly plastic; common roots; many fine tubular pores; neutral; abrupt, smooth boundary.

Ap2-4 to 9 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, coarse, platy structure; soft, friable, slightly plastic; common roots; many fine tubular pores; neutral; abrupt, smooth boundary.

C1-9 to 15 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine tubular pores; neutral; gradual, wavy boundary.

C2-15 to 30 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; common fine tubular pores; mildly alkaline; abrupt, wavy boundary.

C3ca-30 to 64 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; common fine tubular pores; strong effervescence; moderately alkaline.

The Ap and C1 horizons have value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. The C2 and C3 horizons have value of 5 or 6 dry and 3 or 4 moist and chroma of 2 or 3. In some areas the soil is thinly stratified with sandy loam.

Included with this soil in mapping are small areas of Onyx, Toppenish, Umapine, and Warden soils and a few areas of soils that have gravel at a depth of 30 to 60 inches. Also included are soils that are somewhat poorly drained, are strongly alkaline, and in places are heavy silt loam.

In places the water table is at a depth of 3 to 5 feet during the irrigation season. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. The soil holds 10 to 13 inches of water that plants can use. Capability unit I-1 irrigated.

Esquatzel silt loam, 2 to 5 percent slopes (EtB).Except for slope, this soil is similar to Esquatzel silt loam, 0 to 2 percent slopes. Many areas are long and narrow and are cut by stream channels. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIe-1 irrigated.

Esquatzel fine sandy loam, 0 to 2 percent slopes (EsA).-This soil is similar to Esquatzel silt loam, 0 to 2 percent slopes, but the surface layer in most areas is 4 to 9 inches thick. Runoff is slow, and the hazard of water erosion is slight. Soil blowing is a slight hazard where the soil is bare of vegetation. Capability unit I-1 irrigated.

Fiander Series

The Fiander series consists of deep, nearly level, somewhat poorly drained, saline-alkali soils that formed in alluvium on bottom land. The natural vegetation is principally inland saltgrass, basin wildrye, and black greasewood. Elevations range from 650 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Toppenish, Track, and Umapine soils.

In a representative profile, the surface layer is grayish-brown silt loam about 4 inches thick. The subsoil is brown and grayish-brown silty clay loam and heavy silt loam about 24 inches thick. It is very strongly alkaline and strongly alkaline. The substratum is brown silt loam to a depth of 61 inches.

Some areas of Fiander soils have been drained and are irrigated.

Fiander silt loam (Fe).-This soil is on alluvial plains generally parallel to Satus and Toppenish Creeks and their tributaries. In most places the slope is less than 1 percent. A representative profile is about 250 feet northeast of State Route 22 and Marion Drain, NE1/4SW1/4 sec. 29, T. 10 N., R. 21 E., W. M.

A11-0 to 3 inches, grayish-brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak, thin, platy structure; soft, friable, slightly plastic; many roots; slight effervescence; mildly alkaline; abrupt, smooth boundary.

A12-3 to 4 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, platy structure; slightly hard, firm, slightly sticky and slightly plastic; common roots; many fine pores; slight

effervescence; moderately alkaline; abrupt, broken boundary.

B2lt-4 to 12 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; very dark brown (10YR 2/2) moist color on interfaces of peds; strong, medium, prismatic structure; very hard, very firm, sticky and plastic; common roots, mostly matted in the interfaces; very few fine pores; thin continuous clay films on peds; strong effervescence; very strongly alkaline; gradual, wavy boundary.

B22tca-12 to 24 inches, brown (10YR 5/3) heavy silt loam, dark brown (10YR 3/3) moist; common, medium, faint mottles; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; common roots; common fine pores; thin continuous clay films on peds; violent effervescence; very strongly alkaline; gradual, wavy boundary.

B3ca-24 to 35 inches, brown (10YR 5/3) heavy silt loam, dark brown (10YR 3/3) moist; common, medium, faint mottles; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; few roots; common fine pores; disseminated and segregated mycelial lime; strong effervescence; strongly alkaline; gradual, wavy boundary.

C-35 to 61 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; common, medium, faint mottles; massive; slightly hard, friable, sticky and plastic; few roots; common fine pores; about 3 percent rounded pebbles and cobbles; mildly alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It is mildly alkaline to very strongly alkaline. The B horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. It ranges from heavy silt loam to silty clay loam in texture and from 9 to 45 inches in thickness. The structure ranges from strong, medium, prismatic to moderate, medium, subangular blocky. Reaction ranges from strongly alkaline to very strongly alkaline. The C horizon is mildly alkaline to very strongly alkaline.

Included with this soil in mapping are small areas of Kittitas, Toppenish, and Track soils and a few areas of poorly drained soils.

The seasonal high water table is at a depth of 1 to 2 feet, but in places it is within a depth of 1 foot. In irrigated areas the water table is lowered to a depth of 3 to more than 5 feet by deep drains. Permeability is slow. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 8 to 12 inches of water that plants can use. Capability unit IVw-1 irrigated.

Fiander silty clay loams (Fn).-This soil is similar to Fiander silt loam, but the surface layer differs in texture. The soil is in low-lying swales and basins. Runoff is very slow to ponded, and the hazard of erosion is none to slight. Capability unit IVw-1 irrigated.

Fiander loamy fine sand (Fd).-This soil is similar to Fiander silt loam, but the surface layer is windblown hummocky loamy fine sand. Slopes are 0 to 5 percent. Runoff is very slow, and the hazard of water erosion is none to slight. The hazard of soil blowing is high. Capability unit IVw-1 irrigated.

Hezel Series

The Hezel series consists of deep, somewhat excessively drained soils that formed in eolian sand over lake sediments. These soils are on dunelike terraces. Slopes are 0 to 15 percent. The native vegetation is thin stands of Indian ricegrass, needleandthread, and rabbitbrush. Elevations range from 650 to 300 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Quincy and Warden soils.

In a representative profile, the upper 29 inches is grayishbrown loamy fine sand, and the next 19 inches is light

brownish-gray silt loam. Below this, to a depth of 60 inches, is gray loamy sand thinly stratified with light brownish gray silt loam.

Most of the acreage of Hezel soils is irrigated.

Hezel loamy fine sand, 0 to 2 percent slopes (HeA).This soil is on terraces in the vicinity of Satus and Mabton. Slopes are about 1 percent, mostly mechanically leveled. A representative profile is about 150 feet east of Winnier Road and 100 feet south of Spedis Road, NW1/4NW1/4 sec. 33, T. 9 N., R. 22 E., W. M.

C1-0 to 11 inches, grayish-brown (10YR 5/3) loamy fine sand, very dark grayish brown (10YR 3/2) moist; single grained; loose; many roots to a depth of 4 inches and common roots to a depth of 11 inches; slight effervescence; mildly alkaline; gradual, wavy boundary.

C2-11 to 29 inches, grayish-brown (10YR 5/3) loamy fine sand, very dark grayish brown (10YR 3/2) moist; single grained; loose; few roots; strong effervescence; mildly alkaline; clear, wavy boundary.

IIC3ca-29 to 48 inches, light brownish-gray (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) moist; massive, some laminated layers; hard, firm, slightly sticky and slightly plastic; few roots, mostly matted in cracks or fractures; common fine pores; violent effervescence; some lenses and veins of light-gray (10YR 7/2) free lime; strongly alkaline; abrupt, smooth boundary.

IIC4ca-48 to 60 inches, gray (10YR 6/1) loamy sand, very dark grayish brown (10YR 3/2) moist; single grained; violent effervescence; several continuous and discontinuous layers less than 2 inches thick, similar to IIC3ca horizon; strongly alkaline.

The upper part of the C horizon, formed in eolian sand, ranges from loamy sand to loamy very fine sand and is 15 to 35 inches thick. The extent of stratification in the IIC3ca horizon varies widely. In places the IIC3ca horizon extends to a depth of 60 inches or more.

Included with this soil in mapping are areas of Quincy and Warden soils. Also included are a few small areas of wet soils and a few areas of saline-alkali soils. Much of the acreage has been leveled, and the leveling has resulted in altered soil layers. In many areas the leveled soil is calcareous at the surface, and in a few areas leveling cuts in excess of 5 feet have exposed old lake sediments. This soil is somewhat excessively drained.

Permeability is moderate. Runoff is very slow, and the hazard of water erosion is none to slight. The hazard of soil blowing is high where the soil is bare of vegetation. The soil holds 5 to 11 inches of water that plants can use. Capability unit IVE-2 irrigated.

Hezel loamy fine sand, 2 to 15 percent slopes (HeD).Except for slope, this soil is similar to Hezel loamy fine sand, 0 to 2 percent slopes. The slope is about 7 percent. The topography is mostly rolling. Included in mapping are small areas of Quincy and Warden soils and dune land.

Runoff is slow to medium, and the hazard of water erosion is slight to moderate. The hazard of soil blowing is severe where the soil is bare of vegetation. The mantle of windblown sand is only about 15 inches thick on the southwest exposures and about 33 inches thick on the northeast exposures. Capability unit IVE-2 irrigated.

Kittitas Series

The Kittitas series consists of deep, somewhat poorly drained, saline-alkali soils that formed in alluvium. These soils are on low alluvial plains. Slopes are 0 to 2 percent. The native vegetation is principally black greasewood and inland saltgrass. Elevations range from 700 to 1,000 feet. The mean annual precipitation is 6 to 9 inches, the mean

annual air temperature is 47° to 51° F., and the frost, free season is 130 to 180 days. These soils are associated with Ahtanum, Onyx, Toppenish, and Yost soils.

In a representative profile, the surface layer is gray, very dark gray, and dark grayish-brown silt loam about 18 inches thick. It is strongly alkaline and very strongly alkaline. The substratum is light brownish-gray and pale-brown, weakly stratified heavy silt loam and silt loam. It is moderately alkaline.

Some areas of Kittitas soils have been drained and are irrigated.

Kittitas silt loam (Ks).-This soil is on alluvial plains generally parallel to Ahtanum, Satus, or Toppenish Creeks or their tributaries. In most places the slope is less than 1 percent. A representative profile is about 1 mile west of U.S. Highway No. 97 and 1,980 feet north of Pump House Road, NE1/4SE1/4 sec. 31, T. 10 N., R. 20 E., W.M.

A11-0 to 2 inches, gray (10YR 5/1) silt loam, black (10YR 2/1) moist; weak, thin, platy structure; soft, friable, slightly sticky and slightly plastic; many inland saltgrass stolons and common roots; slight effervescence; strongly alkaline; clear, smooth boundary.

A12-2 to 7 inches, very dark gray (10YR 4/1) silt loam, black (10YR 2/1) moist; weak, medium, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; strong effervescence; very strongly alkaline; gradual, wavy boundary.

A13-7 to 18 inches, dark grayish brown (10YR 4/2) heavy silt loam, very dark brown (10YR 2/2) moist; moderate, fine, subangular blocky structure that parts to strong, fine, granular structure; hard, firm, sticky and plastic; common roots; common fine pores; violent effervescence; strongly alkaline; gradual, wavy boundary.

C1ca-18 to 24 inches, light brownish-gray (10YR 6/2) heavy silt loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, sticky and plastic; few roots; many fine pores; violent effervescence; some light-gray (10YR 7/2) disseminated lime; some black (10YR 2/1), moist, old root channels; moderately alkaline; abrupt, wavy boundary.

C2-24 to 34 inches, pale-brown (10YR 6/3) heavy silt loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable, sticky and plastic; few roots; many fine and medium pores; slight effervescence; moderately alkaline; gradual, wavy boundary.

C3-34 to 63 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; many fine and medium pores to a depth of 53 inches; water table at a depth of 53 inches; moderately alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It ranges from 10 to 24 inches in thickness. It is normally very strongly alkaline, but in some drained and irrigated areas it is moderately alkaline. Reaction generally decreases with depth. The C horizon has value of 3 or 4 moist and chroma of 2 or 3 moist.

The Cca horizon is missing in some areas. In places the C horizon has thin layers of fine sandy loam and silty clay loam. The soil is generally more than 60 inches deep, but in places it is underlain by very gravelly sand below a depth of 40 inches.

Included with this soil in mapping are small areas of Ahtanum, Onyx, and Toppenish soils and some areas of poorly drained soils.

The seasonal high water table is at a depth of 1 to 2 feet and in a few places is within a depth of 1 foot. In irrigated areas the water table is held to a depth of 3 to more than 5 feet by deep drains. Permeability is moderate. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 8 to 13 inches of water that plants can use. Capability unit IIw-1 irrigated.

Kittitas silty clay loam (Kt).-This soil is similar to Kittitas silt loam, but the surface layer differs in texture and

is 7 to 12 inches thick. Some faint mottles are generally in the surface layer. Included in mapping are small areas of Toppenish silty clay and Yost clay and some areas of poorly drained soils. Runoff is very slow to ponded, and the hazard of erosion is none to slight. Capability unit IIw-1 irrigated.

Logy Series

The Logy series consists of deep, well-drained soils that formed in mixed alluvium. Some loess is in the surface layer in places. These soils are on alluvial plains. Slopes are 0 to 5 percent. The native vegetation is principally big sagebrush, bitterbrush, lupine, and annual grasses. Elevations range from 700 to 1,200 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 170 days. These soils are associated with Onyx and Simcoe soils.

In a representative profile, the surface layer is dark grayish-brown silt loam about 12 inches thick. The subsoil is dark grayish-brown gravelly loam about 7 inches thick. The substratum, to a depth of about 39 inches, is dark-brown weakly stratified very gravelly sandy loam. Below this, to a depth of 60 inches, it is brown very gravelly coarse sand. The soil is neutral to mildly alkaline.

Part of the acreage of Logy soils is irrigated.

Logy silt loam (Lg).-This soil is mostly on the alluvial flood plain south and west of White Swan. The slope is about 2 percent. A representative profile is about three-fourths of a mile west of State Route 220 and one-half mile south of Pine Cone Road, 3 miles southwest of White Swan, NE1/4SW1/4NW1/4 sec. 14, T. 10 N., R. 16 E., W.M.

A11-0 to 2 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; many fine roots; common fine pores; neutral; abrupt, smooth boundary.

A12-2 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; common fine roots; common fine pores; approximately 5 percent gravel; neutral; gradual, wavy boundary.

B2-12 to 19 inches, dark grayish-brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; 40 percent gravel and cobbles; mildly alkaline; gradual, wavy boundary.

IIC1-19 to 39 inches, dark-brown (10YR 4/3) very gravelly sandy loam, dark brown (10YR 3/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few fine roots; 65 percent gravel and cobbles, some of which have a light-gray (10YR 7/2) lime silica coating on the lower side; mildly alkaline; abrupt, wavy boundary.

IIC2-39 to 60 inches, brown (10YR 5/3) very gravelly coarse sand, dark brown (10YR 3/3) moist; single grained; loose; 90 percent gravel and cobbles; neutral.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It is 4 to 18 inches thick. Reaction is neutral to mildly alkaline. The C horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 2 through 4. It is 50 to 90 percent gravel and cobbles.

Included with this soil in mapping are small areas of Onyx and Yakima soils, a few small areas of gravelly and stony soils, and a small acreage of lowland that is seasonally flooded.

This soil is well drained. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. Some areas are flooded by runoff early in spring. The soil holds 2 to 5 inches of water that plants can use. Capability unit IIIs-1 irrigated.

Logy cobble silt loam (Lo).-This soil is similar to Logy silt loam, but the surface layer is cobbly and gravelly. In many areas the soil is dissected by very cobbly and very stony intermittent stream channels. It is also dissected by old abandoned stream channels filled with cobbles. Included in mapping are small areas of Logy, Onyx, and Yakima soils. Runoff is slow, and the hazard of erosion is slight. Most areas are flooded annually by runoff from higher areas early in spring. Capability unit VIw-1 nonirrigated.

Naches Series

The Naches series consists of well-drained soils that formed in old alluvium. These soils are on old alluvial plains. Slopes are 0 to 5 percent. The native vegetation is mainly cheatgrass, bluebunch wheat grass, big sagebrush, and rabbitbrush. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Ashue, Toppenish, Track, and Weirman soils.

In a representative profile, the surface layer is brown loam about 10 inches thick. The subsoil is brown sandy clay loam about 11 inches thick. The substratum is brown loam and light brownish-gray fine sandy loam to a depth of 38 inches and gray very gravelly sand to a depth of 65 inches. The soil is mildly alkaline or moderately alkaline.

Most of the acreage of Naches soils is irrigated.

Naches loam, 0 to 2 percent slopes (NaA).-Most areas of this soil have been leveled. Generally the slope is about 1 percent. A representative profile is about 200 feet north of Fort Road and 2,000 feet east of Lateral C Road, SE1/4SW1/4 sec. 1, T. 10 N., R. 18 E., W.M.

Ap1-0 to 5 inches, brown (10YR 5/3) loam, dark brown (10YR. 3/3) moist; weak, fine, granular structure; hard, friable, slightly sticky and slightly plastic; many roots; many fine tubular pores; mildly alkaline; abrupt, smooth boundary.

Ap2-5 to 10 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; massive; very hard, firm, slightly sticky and slightly plastic; many roots matted on the top and in fractures; many fine tubular pores; mildly alkaline; abrupt, wavy boundary.

B2t-10 to 21 inches, brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) moist; moderate, medium and coarse, prismatic structure; hard, friable, sticky and plastic; common roots; few fine pores; thin discontinuous clay films on peds; mildly alkaline; gradual, wavy boundary.

C1-21 to 34 inches, brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common roots; many fine pores; few pebbles; mildly alkaline; abrupt, wavy boundary.

C2ca-34 to 38 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) moist; massive; soft, very friable; common roots; common fine pores; few pebbles; violent effervescence; moderately alkaline; abrupt, wavy boundary.

IIC3-38 to 65 inches, gray (10YR 5/1) very gravelly sand, very dark gray (10YR 3/1) moist; single grained; loose; 80 percent gravel; moderately alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. It is loam or silt loam. In some areas a well-defined tillage pan, or plowpan, has formed. The B2t horizon ranges from heavy silt loam to clay loam or sandy clay loam and has moderate blocky or moderate prismatic structure. The C1 and C2ca horizons are loam, silt loam, or fine sandy loam and in places are gravelly. The IIC3 horizon ranges from sandy loam to sand that is 40 to 80 percent gravel.

Included with this soil in mapping are small very gravelly areas and small areas of Ashue, Toppenish, Track, and Weirman soils.

Permeability is moderately slow in the surface layer, the subsoil, and the upper part of the substratum and very rapid in the lower part of the substratum. Runoff is slow, and the hazard of erosion is slight. The soil holds 6 to 8 inches of water that plants can use. Capability unit Its-1 irrigated.

Naches loam, 2 to 5 percent slopes (NaB).-Except for slope, this soil is similar to Naches loam, 0 to 2 percent slopes. It is gently undulating. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit Ile-1 irrigated.

Onyx Series

The Onyx series consists of well-drained, deep soils that formed in recent alluvium. These soils are on bottom land. Slopes are 0 to 5 percent. Much of the bottom land is incised by perennial or intermittent stream channels. The native vegetation is mainly cottonwood, willow, and alder trees. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with the Esquatzel, Kittitas, Logy, Simcoe, and Yakima soils.

In a representative profile, the surface layer is grayish-brown silt loam about 6 inches thick. The substratum is grayish-brown, dark grayish-brown, and brown, weakly stratified silt loam to a depth of 64 inches. It is mildly alkaline.

Most of the acreage of Onyx soils is irrigated.

Onyx silt loam, 0 to 2 percent slopes (OnA).-This soil is in low areas parallel to Ahtanum, Toppenish, and Satus Creeks or their tributaries. In most places the slope is less than 1 percent. A representative profile is about 100 feet east of Plank Road and 1,400 feet north of Satus Creek, NW1/4SE1/4 sec. 5, T. 9 N., R. 21 E., W.M.

Ap-0 to 6 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; many fine tubular pores; moderately alkaline; abrupt, smooth boundary.

C1-6 to 22 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, medium, sub angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; abrupt, smooth boundary.

C2-22 to 30 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; abrupt, smooth boundary.

C3-30 to 64 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline.

The A horizon when moist ranges from dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) and from very fine sandy loam to silt loam. It is neutral to mildly alkaline.

Included with this soil in mapping are small areas of Esquatzel, Kittitas, Logy, and Zillah soils and small areas of calcareous, poorly drained soils.

During the irrigation season, the water table is at a depth of 3 to 5 feet in places. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. The soil holds 11 to 13 inches of water that plants can use. Capability unit I-1 irrigated.

Onyx silt loam, 2 to 5 percent slopes (OnB).-Except for slope, this soil is similar to Onyx silt loam, 0 to 2 percent slopes. Most areas are long and narrow and are cut by stream

channels. Runoff is slow to medium, and the hazard of erosion is slight to moderate. In places streambank erosion is a severe hazard during periods of high water. Capability unit IIE-1 irrigated.

Quincy Series

The Quincy series consists of somewhat excessively drained soils that formed in deep eolian sand. Relief is ridged, hummocky, and dunelike. Slopes are 0 to 15 percent. The native vegetation is a thin stand of Indian ricegrass, needleand-thread, and rabbitbrush. Elevations range from 650 to 750 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47 to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Hezel and Warden soils.

In a representative profile, the soil is grayish-brown loamy fine sand to a depth of 50 inches. Below this, to a depth of 62 inches, it is light brownish-gray loamy very fine sand. The soil is mildly alkaline to moderately alkaline.

Most of the acreage of Quincy soils is irrigated.

Quincy loamy fine sand, 2 to 15 percent slopes (QuD). -This soil is on dunelike terraces west of Mabton and south and west of Satus. If the soil is not cultivated, the surface is hummocky and blowouts are common. In most places the slope is about 5 percent. A representative profile is about 100 feet east of Bond Road and 1,400 feet south of State Route 22, SW1/4NE1/4 sec. 33, T. 9 N., R. 22 E., W.M.

C11-0 to 5 inches, grayish-brown (10YR 5/2) loamy sand, dark grayish brown (10YR 4/2) moist; single grained; loose when dry and moist; many roots; mildly alkaline; gradual, wavy boundary.

C2-5 to 16 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose when dry and moist; common roots; mildly alkaline; gradual, wavy boundary.

C3-16 to 41 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose when dry and moist; few roots; mildly alkaline; abrupt, wavy boundary.

C4-41 to 50 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose when dry and moist; few roots; slight effervescence; moderately alkaline.

C5ca-50 to 62 inches, light brownish-gray (10YR 6/2) loamy very fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose when dry and moist; few roots; violent effervescence; moderately alkaline.

The upper 40 inches of this soil is sand, loamy sand, or loamy fine sand. In some areas it has a moist value of 3. In some places the soil is noncalcareous throughout, but in others it is calcareous throughout.

Included with this soil in mapping are small areas of Hezel and Warden soils and a few small areas of somewhat poorly drained and strongly alkaline soils.

Permeability is rapid. Runoff is slow to medium, and the hazard of water erosion is slight to moderate. The hazard of soil blowing is severe where the soil is bare of vegetation. The soil holds 5 to 7 inches of water that plants can use. Capability unit IVE-2 irrigated.

Quincy loamy fine sand, 0 to 2 percent slopes (QuA). -Except for slope, this soil is similar to Quincy loamy fine sand, 2 to 15 percent slopes. It is on broad ridgetops or on low terraces. Runoff is very slow, and the hazard of erosion is none to slight. The hazard of soil blowing is severe where the soil is bare of vegetation. In places the soil is hummocky, but extensive blowouts are uncommon.

In areas that are leveled and prepared for irrigation the original layers have been altered enough to destroy their normal sequence. In many places the leveled soils are calcareous to the surface. In a few areas leveling cuts in excess of 5 feet have exposed variable substratum material, such as old lake sediments. Capability unit IVE-2 irrigated.

Ritzville Series

The Ritzville series consists of deep, well-drained soils that formed in wind-laid material mixed with small amounts of volcanic ash. These soils are on uplands. Slopes are 0 to 65 percent. The native vegetation is principally big sagebrush, rabbitbrush, and bunchgrasses. Elevations range from 1,000 to 1,500 feet. The mean annual precipitation is about 9 inches, the mean annual air temperature is 47 to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel and Shano soils.

In a representative profile, the surface layer is grayish-brown silt loam 9 inches thick. The subsoil is brown silt loam about 24 inches thick. The substratum is brown and pale-brown silt loam to a depth of 61 inches.

Most of the acreage of Ritzville soils is irrigated.

Ritzville silt loam, 2 to 5 percent slopes (RtB). -This soil is on uplands, mainly on the north slopes of Ahtanum Ridge. In most places the slope is about 4 percent. A representative profile is about 500 feet south of South Ahtanum Road and one-half mile east of Pioneer Road, NW1/4NW1/4 sec. 17, T. 12 N., R. 18 E., W.M.

Ap-0 to 9 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

B21-9 to 26 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; neutral; gradual, wavy boundary.

B22-26 to 33 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, sticky and slightly plastic; few roots; many fine pores; weakly cemented silt concretions (cicadalike nodules) 1/2 inch to 2 inches in length and width; neutral; gradual, wavy boundary.

C1-33 to 40 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline; gradual, wavy boundary.

C2-40 to 50 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline; gradual, wavy boundary.

C3-50 to 61 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; hard, firm, slightly sticky and slightly plastic; few roots; common fine pores; mildly alkaline.

The A and B horizons have value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. The A horizon ranges from *very* fine sandy loam to silt loam in texture and from 6 to 12 inches in thickness. The B horizon ranges from 10 to 30 inches in thickness. In places the lower part of the B horizon and the C horizon have weakly cemented silt concretions. In places the lower part of the C horizon is strongly calcareous, but in most areas it is weakly calcareous or noncalcareous. The soil ranges from 40 inches to more than 60 inches in thickness and is underlain by a cemented hardpan, basalt bedrock, or variable unrelated material weathered from the Ellensburg Formation.

The depth to lime in this soil is more than 43 inches, which is deeper than is defined as the range for the series. This difference, however, does not significantly alter the use and behavior of the soil.

Included with this soil in mapping are small areas of Esquatzel soils, areas of the Ritzville gravelly subsoil variant, and a few areas where the slope is less than 2 percent.

Permeability is moderate. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The soil holds 11 to 13 inches of water that plants can use. Capability unit IIe-1 irrigated.

Ritzville silt loam, 5 to 8 percent slopes (RtC). Except for slope, this soil is similar to Ritzville silt loam, 2 to 5 percent slopes. Runoff is medium, and the hazard of erosion is moderate. Capability unit IIIe-1 irrigated.

Ritzville silt loam, 8 to 15 percent slopes (RtD). Except for slope, which is generally about 10 percent, this soil is similar to Ritzville silt loam, 2 to 5 percent slopes. Runoff is rapid, and the hazard of erosion is high. Capability unit IVe-3 irrigated.

Ritzville silt loam, 15 to 30 percent slopes (RtE). This soil is similar to Ritzville silt loam, 2 to 5 percent slopes, but differs in slope and in depth to the substratum. On west exposures the depth is 12 to 20 inches, and on north and east exposures 20 to 40 inches. Included in mapping are areas of Esquatzel soils, areas of the Ritzville gravelly subsoil variant, and small areas of stony and severely eroded soils. Runoff is very rapid, and the hazard of erosion is very severe. Capability unit VIe-1 irrigated.

Ritzville silt loam, 30 to 65 percent slopes (RtF). This soil is similar to Ritzville silt loam, 2 to 5 percent slopes, but differs in slope and in depth to the substratum. On west exposures the depth is 12 to 20 inches, and on north and east exposures 20 to 40 inches. Included in mapping are areas of Esquatzel soils, areas of the Ritzville gravelly subsoil variant, areas where rock crops out, and small areas of stony and severely eroded soils. Runoff is very rapid, and the hazard of erosion is very severe. Capability unit VIe-1 irrigated.

Ritzville Series, Gravelly Subsoil Variant

The Ritzville gravelly subsoil variant consists of deep, well-drained soils that formed in wind-laid material over gravelly or stony alluvium, sandstone, or basalt bedrock. These soils are on uplands and alluvial fans. Slopes are 5 to 15 percent. The native vegetation is principally big sagebrush, rabbitbrush, and bunchgrasses. Elevations range from 1,000 to 1,500 feet. The mean annual precipitation is about 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 150 days. These soils are associated with Esquatzel and Ritzville soils.

In a representative profile, the surface layer is grayish-brown silt loam about 9 inches thick. The subsoil is brown silt loam about 13 inches thick. The substratum is yellowishbrown very cobbly silt loam to a depth of 60 inches.

Most of the acreage of this soil is irrigated.

Ritzville silt loam, gravelly subsoil variant, 8 to 15 percent slopes (RuD). This soil is on uplands and alluvial fans on the north slopes of Ahtanum Ridge. In most places the slope is about 10 percent. A representative profile is about 500 feet south of South Ahtanum Road and 50 feet west of South Wiley Road, SE1/4SE1/4 sec. 14, T. 12 N., R. 17 E., W. M.

A1-0 to 6 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

Ap2-6 to 9 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure; hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; neutral; abrupt, smooth boundary.

B2-9 to 22 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; few fine pores; neutral; abrupt, wavy boundary.

IIC-22 to 60 inches, yellowish-brown (10YR 5/4) very cobbly silt loam, brown (10YR 3/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common roots matted on stone faces; common fine pores; 70 percent gravel, cobbles, and stones; neutral.

The A and B horizons have value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3 moist or dry. The A horizon ranges from very fine sandy loam to silt loam. In places the lower part of the B horizon has weakly cemented silt concretions. In places the IIC horizon is very gravelly silt loam. Depth to the IIC horizon ranges from 15 inches to 38 inches.

Included with this soil in mapping are small areas of Esquatzel and Ritzville soils and small areas that are gravelly or stony on the surface. Also included are small areas where basalt is at a depth of 20 to 40 inches and areas of soils that have a substratum of sand or one that is cemented by lime and silica.

Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. The soil holds 6 to 8 inches of water that plants can use. Capability unit IVe-3 irrigated.

Ritzville silt loam gravelly subsoil variant, 5 to 8 percent slopes (RuC). Except for slope, this soil is similar to Ritzville silt loam, gravelly subsoil variant, 5 to 15 percent slopes. Included in mapping are a few areas where the slope is 2 to 5 percent. Runoff is medium, and the hazard of erosion is moderate. Capability unit IIIe-1 irrigated.

Rock Creek Series

The Rock Creek series consists of well-drained, shallow soils that formed in material weathered from basalt mixed with loess. These soils are on uplands. Slopes are 0 to 20 percent. The native vegetation is mainly buckwheat, phlox, and Sandberg bluegrass, but about 50 percent or more of the surface area is bare of vegetation. Elevations range from 1,000 to 1,400 feet. The mean annual precipitation is 9 to 12 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 120 to 170 days. These soils are associated with Logy and Simcoe soils.

In a representative profile, the surface layer is reddish-brown very stony loam about 2 inches thick. The subsoil is reddish-brown and dark-brown very stony and very cobbly clay loam and clay about 12 inches thick. Basalt bedrock is at a depth of 14 inches.

Rock Creek soils are not suitable for cultivation because they are too shallow and stony. They are used for grazing and wildlife habitat.

Rock Creek very stony loam, 0 to 20 percent slopes (RvE). This soil is on uplands near Fort Simcoe and Medicine Valley. A representative profile is about threefourths of a mile east of Ft. Simcoe and 600 feet north of State Route 3B, SW1/4SE1/4 sec. 16, T. 10 N., R. 16 E., W.M.

A1-0 to 2 inches, reddish-brown (5YR 5/3) very stony loam, dark reddish brown (5YR 3/3) moist; weak, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; many fine vesicular pores; 30 percent gravel, cobbles, and stones; neutral; abrupt, smooth boundary.

B21t-2 to 7 inches, reddish-brown (5YR 5/4) very stony clay loam, reddish brown (5YR 3/4) moist; weak, coarse, platy structure; hard, firm, sticky and plastic; common roots; many fine vesicular pores; 30 percent gravel, cobbles, and stones; neutral; gradual, wavy boundary.

B22t-7 to 10 inches, reddish-brown (5YR 5/4) very cobbly clay loam, reddish brown (5YR 3/4) moist; massive; hard, firm, sticky and plastic; few matted roots between stones; 70 percent gravel, cobbles, and stones; neutral; abrupt, wavy boundary.

B23t-10 to 14 inches, dark-brown (7.5YR 4/4) very cobbly clay, dark brown (7.5YR 3/4) moist; massive; extremely hard, firm, very sticky and plastic; 90 percent gravel, cobbles, and stones; neutral; gradual, wavy boundary.

R-14 inches, fractured basalt bedrock.

A11 horizons have value of 4 or 5 dry, chroma of 3 or 4, and hue of 5YR or 7.5YR. The solum is 30 to 90 percent gravel, cobbles, and stones. Depth to basalt bedrock generally is 8 to 20 inches.

Included with this soil in mapping are small areas of Logy, Onyx, and Simcoe soils and soils that are shallow over cemented gravel.

Permeability is moderately slow. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The soil holds 1 to 2 inches of water that plants can use. Capability unit VIIc-1 nonirrigated.

Shano Series

The Shano series consists of deep, well-drained soils that formed in silty wind-laid deposits mixed with small amounts of volcanic ash. These soils are on uplands. Slopes are 0 to 30 percent. The native vegetation is principally big sagebrush, rabbitbrush, and bunchgrasses. Elevations range from 600 to 1,300 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47 to 51 F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel and Warden soils.

In a representative profile, the surface layer is grayish-brown and brown silt loam about 5 inches thick. The subsoil is brown silt loam about 13 inches thick. The substratum is pale-brown silt loam to a depth of 47 inches. Below this, to a depth of 55 inches, it is calcareous, very pale brown silt loam underlain by a light-gray, lime-silica cemented gravel hardpan.

Most of the acreage of Shano soils is irrigated.

Shano silt loam, 5 to 8 percent slopes (ShC).-This soil is on uplands. It makes up much of the irrigated area on the lower slopes of the Toppenish and Ahtanum Ridges. In most places the slope is about 6 percent. A representative profile is about one-half mile east of Wesley Road and one-fourth mile south of Evans Road, NE1/4NW1/4 sec. 19, T. 11 N., R. 17 E., W.M.

A11-0 to 2 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, thin, platy structure; soft, friable, slightly sticky and slightly plastic; many fine roots; many fine pores; neutral; abrupt, smooth boundary.

A12-2 to 5 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, medium, platy structure; soft, friable, slightly sticky and slightly plastic; common roots; few fine pores; neutral; gradual, wavy boundary.

B2-5 to 18 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; few roots in peds, common roots along ped faces; few fine pores; mildly alkaline; gradual, wavy boundary.

C1-18 to 29 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; few fine pores; mildly alkaline; gradual, wavy boundary.

C2-29 to 47 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; few fine pores; moderately alkaline; gradual, wavy boundary.

C3ca-47 to 55 inches, very pale brown (10YR 7/3) silt loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few roots; few fine pores; strong effervescence; moderately alkaline; abrupt, wavy boundary.

IIC4sim-55 to 60 inches, light-gray (10YR 7/2) lime-silica cemented gravel.

The A and B horizons have value of 5 or 6 dry and 3 or 4 moist and chroma of 2 or 3. The A horizon ranges from 3 to 8 inches in thickness, and the B horizon from 10 to 20 inches. The C horizon has value of 5 through 7 dry and 4 or 5 moist and chroma of 2 or 3. Depth to the calcareous layer ranges from 20 to 50 inches. In places the C horizon has hard, concentric, cicadalike nodules. The soil ranges from 40 inches to more than 60 inches in thickness. It is underlain by a hardpan, basalt bedrock, or variable unrelated material weathered from the Ellensburg Formation.

Included with this soil in mapping are small areas of Esquatzel, Rock Creek, and Warden soils and a few areas of saline-alkali soils.

Permeability is moderate. Runoff is medium, and the hazard of erosion is moderate. The soil holds 11 to 13 inches of water that plants can use. Capability unit IIIe-1 irrigated.

Shano silt loam, 0 to 2 percent slopes (ShA).-Except for slope, this soil is similar to Shano silt loam, 5 to 8 percent slopes. The slope is generally about 1 percent. Runoff is slow, and the hazard of erosion is slight. Capability unit I-1 irrigated.

Shano silt loam, 2 to 5 percent slopes (ShB).-Except for slope, this soil is similar to Shano silt loam, 5 to 8 percent slopes. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIe-1 irrigated.

Shano silt loam, 8 to 15 percent slopes (ShD).-This soil is similar to Shano silt loam, 5 to 8 percent slopes, but it differs in slope and in depth to the substratum. On south exposures the depth is 12 to 20 inches and on north exposures 20 to 35 inches. Runoff is rapid, and the hazard of erosion is severe. Capability unit IVe-3 irrigated.

Shano silt loam, 15 to 30 percent slopes (ShE).-This soil is similar to Shano silt loam, 5 to 8 percent slopes, but is more sloping and is stony in some areas and severely eroded in others. Runoff is very rapid, and the hazard of erosion is very severe. Capability unit VIe-1 irrigated.

Simcoe Series

The Simcoe series consists of moderately deep, well-drained soils that formed in wind-laid silts, volcanic ash, and material weathered from basalt. These soils are on low uplands. Slopes are 0 to 8 percent. The natural vegetation is mainly big sagebrush, cheatgrass, bunchgrass, and balsamroot. Elevations range from 1,000 to 1,400 feet. The mean annual precipitation is 9 to 12 inches, the mean annual temperature is 47 to 51 F., and the frost-free season is 120 to 170 days. These soils are associated with Rock Creek soils.

In a representative profile, the surface layer is grayish-brown silt loam about 8 inches thick. The subsoil is about 29 inches thick. The upper 6 inches is grayish-brown heavy silt loam, the next 11 inches is brown silty clay loam, and the lower 12 inches is light yellowish-brown clay loam. Basalt bedrock is at a depth of 37 inches.

Most of the acreage of Simcoe soils is irrigated.

Simcoe silt loam, 0 to 2 percent slopes (SmA).-This soil is on the more elevated uplands of irrigated areas near

Fort Simcoe. In most places the slope is about 1.5 percent. A representative profile is about 2,000 feet north of State Route 3B and 200 feet east of Toppenish Lateral Canal, NW1/4NE1/4SE1/4 sec. 15, T. 10 N., R. 16 E., W.M.

Ap-0 to 8 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

B21t-8 to 14 inches, grayish-brown (10YR 5/2) heavy silt loam, very dark grayish brown (10YR 3/2) moist; moderate, coarse, prismatic structure; hard, friable, sticky and plastic; common roots; common fine pores; few thin to moderately thick clay films; neutral; gradual, wavy boundary.

B22t-14 to 25 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 3/3) moist; weak, coarse, prismatic structure; hard, friable, sticky and plastic; few roots; common fine pores; neutral; gradual, wavy boundary.

B3-25 to 37 inches, light yellowish-brown (10YR 6/4) clay loam, dark yellowish brown (10YR 4/4) moist; massive; hard, firm, very sticky and very plastic; few roots; few fine pores; neutral; abrupt, wavy boundary.

R-37 inches, basalt bedrock.

The A horizon has value of 4 or 5 dry and chroma of 2 or 3. It has granular to subangular blocky structure. The B2 horizon is silt loam or silty clay loam and has moderate, coarse, prismatic to moderate, blocky structure. Depth to basalt bedrock is 30 to 40 inches.

Included with this soil in mapping are small areas of Logy, Rock Creek, and Shano soils. Also included are small areas of soils similar to this Simcoe soil, but more than 40 inches deep and a few small areas of saline-alkali soils.

Permeability is moderately slow. Runoff is slow, and the hazard of erosion is slight. The soil holds 7 to 8 inches of water that plants can use. Capability unit IIs-1 irrigated.

Simcoe silt loam, 2 to 5 percent slopes (SmB). Except for slope, this soil is similar to Simcoe silt loam, 0 to 2 percent slopes. Most areas are gently undulating and are incised in places by intermittent stream channels. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIs-1 irrigated.

Simcoe silt loam, 5 to 8 percent slopes (SmC). Except for slope, this soil is similar to Simcoe silt loam, 0 to 2 percent slopes. Most areas are undulating and are incised in places by steep intermittent stream channels. Runoff is medium, and the hazard of erosion is moderate. Capability unit IIIs-1 irrigated.

Stanfield Series

The Stanfield series consists of moderately well drained, saline-alkali soils that are moderately deep over a silica-cemented hardpan. These soils formed in alluvium. They are on old alluvial plains, locally referred to as second bottoms. In most places slopes are less than 1 percent, but in a few they are as much as 5 percent. The native vegetation is principally black greasewood and inland saltgrass. Many small areas are bare of vegetation. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel and Umapine soils.

In a representative profile, the soil is pale-brown, strongly alkaline and very strongly alkaline silt loam to a depth of 23 inches. It is underlain by a silica-cemented hardpan.

Some areas of Stanfield soils have been drained and are irrigated.

Stanfield silt loam, 0 to 2 percent slopes (StA). Most areas of this soil are adjacent to Plank Road and south of Satus Creek. In most places the slope is about 1 percent. A representative profile is about four-fifths of a mile east of Plank Road and one-half mile north of West Satus Road, SE1/4NW1/4 sec. 9, T. 9 N., R. 21 E., W.M.

A11-0 to 2 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 3/3) moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; violent effervescence; strongly alkaline; abrupt, smooth boundary.

A12-2 to 4 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; moderate, thin, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; many fine pores; strong effervescence; very strongly alkaline; abrupt, smooth boundary.

C1sa-4 to 15 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; soft, friable, slightly sticky and slightly plastic; common roots; few fine pores; strong effervescence; very strongly alkaline; gradual, wavy boundary.

C2si-15 to 23 inches, pale-brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; massive; weakly to strongly cemented; hard, firm, slightly plastic; common roots; few fine pores; some hard concretions that have light-gray (10YR 7/2) lime coatings; violent effervescence on lime-coated concretions; very strongly alkaline; abrupt, wavy boundary.

C3sim-23 to 60 inches, pale-brown (10YR 6/3) indurated hardpan, dark brown (10YR 4/3) moist; massive; some fractures; extremely hard, extremely firm; does not dissolve in HCl or H₂O; few fine pores; some light-gray (10YR 7/2) segregated mycelial lime within the cemented hardpan; strongly alkaline.

The soil material has value of 5 or 6 dry and 2 or 3 moist and chroma of 2 or 3. The hardpan has similar value and chroma, but hue ranges from 5Y through 10YR. The pan is 4 inches to many feet thick. Some areas have multiple, discontinuous cemented layers over a prominent indurated hardpan. Depth to the pan ranges from 20 to 40 inches.

Included with this soil in mapping are small areas of Ahtanum, Esquatzel, and Umapine soils and areas where the hardpan is above a depth of 20 inches. Also included are some areas where the soil is generally bare of vegetation and is covered with a white saline-alkali incrustation.

Generally the seasonal high water table fluctuates between depths of 2 and more than 5 feet, but in some irrigated areas it is above 2 feet. Permeability is moderate above the hardpan and very slow in the pan. Runoff is slow to ponded, and the hazard of erosion is slight. The soil holds about 3 to 5 inches of water that plants can use. Capability unit IVw-1 irrigated.

Stanfield silt loam, 2 to 5 percent slopes (StB). Except for slope, this soil is similar to Stanfield silt loam, 0 to 2 percent slopes. Included in mapping are some ponded areas and some intermittent stream channels. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IVw-1 irrigated.

Stanfield sandy loam (Sn). This soil is similar to Stanfield silt loam, 0 to 2 percent slopes, but the surface layer differs in texture and is 4 to 15 inches thick. Included in mapping are a few small areas of loamy fine sands that are windblown and hummocky. The hummocks are 4 to 30 inches thick. Runoff is slow, and the hazard of water erosion is slight. The hazard of soil blowing is moderate. Capability unit IVw-1 irrigated.

Toppenish Series

The Toppenish series consists of deep, somewhat poorly drained soils that formed in alluvium. These soils are on old alluvial plains. Slopes are 0 to 5 percent. The native vege-

tation is principally water-tolerant grasses and sedges and cottonwood and willow trees. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Kittitas, Naches, Track, and Yost soils.

In a representative profile, the surface layer is dark-gray silt loam about 6 inches thick. The subsoil is about 40 inches thick. The upper part is dark-gray clay loam about 11 inches thick; the middle part is prominently mottled light-brownish gray silt loam about 14 inches thick; and the lower part is prominently mottled grayish-brown clay loam and gravelly clay loam about 15 inches thick. The substratum is brown very gravelly sandy loam to a depth of 62 inches.

Most areas of Toppenish soil have been drained and are irrigated.

Toppenish silt loam, 0 to 2 percent slopes (ToA). This soil is on alluvial plains somewhat parallel to the lower Toppenish and Satus Creeks and the Yakima River. In most places the slope is about 1 percent or less. A representative profile is about three-fourths of a mile south of State Route 22 and 200 feet east of Myers Road, NW1/4NW1/4 sec. 23, T. 10 N., R. 20 E., W.M.

Ap-0 to 6 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) moist; moderate, thin, platy structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; slight effervescence; moderately alkaline; abrupt, smooth boundary.

B1-6 to 17 inches, dark-gray (10YR 4/1) clay loam, very dark gray (10YR 3/1) moist; moderate, medium and coarse, prismatic structure; hard, friable, sticky and plastic; common roots; common fine pores; slickensides on ped; slight effervescence; moderately alkaline; gradual, wavy boundary.

IIB21g-17 to 31 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist; common, medium, prominent, yellowish-red (5YR 5/6) mottles; moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few roots; few medium pores; moderately alkaline; gradual, wavy boundary.

IIB22g-31 to 42 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) moist; common, medium, prominent, dark-brown (7.5YR 4/4) mottles; moderate, medium, subangular blocky structure; hard, friable, sticky and plastic; few roots; few medium pores; few pebbles; mildly alkaline; gradual, wavy boundary.

IIB23g-42 to 46 inches, grayish-brown (10YR 5/2) gravelly clay loam, very dark grayish brown (10YR 3/2) moist; many medium, prominent, reddish-brown (5YR 4/4) mottles; moderate, medium, subangular structure; hard, friable, sticky and plastic; few roots; few medium pores; 40 percent gravel; mildly alkaline; gradual, wavy boundary.

IVC-46 to 62 inches, brown (10YR 5/3) very gravelly sandy loam, dark brown (10YR 3/3) moist; massive; loose; 80 percent gravel; mildly alkaline.

The A and B1 horizons have value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2 moist or dry. They are silt loam, silty clay loam, or clay loam. The B2g horizon has value of 4 through 6 dry and 3 through 5 moist and chroma of 1 or 2 moist or dry. It is silt loam, clay loam, or gravelly clay loam. The C horizon has value of 4 through 6 dry and chroma of 1 through 4 dry. It is sandy loam, sand, or silt loam and is very gravelly in places.

Included with this soil in mapping are small areas of Fiander, Kittitas, Naches, and Track soils, a few areas of poorly drained soils, and a few areas of saline-alkali soils.

Generally the seasonal high water table is at a depth of 1 to 2 feet, but in places it is within a depth of 1 foot. In irrigated areas the water table is maintained at a depth of 3 to 5 feet by deep drains. Permeability is moderate. Runoff is very slow, and the hazard of erosion is none to slight.

The soil holds 8 to 10 inches of water that plants can use. Capability unit IIw-2 irrigated.

Toppenish silt loam, 2 to 5 percent slopes (ToB). Except for slope, this soil is similar to Toppenish silt loam, 0 to 2 percent slopes. The dark-colored surface layer and the upper part of the subsoil are 10 to 15 inches thick. Included in mapping are some well-drained areas, some ponded areas, and some intermittent stream channels. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Individual delineations are mostly long and small. Capability unit IIw-2 irrigated.

Toppenish silty clay loam (Tp). This soil is similar to Toppenish silt loam, 0 to 2 percent slopes, but the dark-colored surface layer and the upper part of the subsoil are clay loam or silty clay loam 6 to 12 inches thick.

Included in mapping are small areas of Kittitas silty clay loam and Yost clay. Runoff is very slow, and the hazard of erosion is none to slight. The soil provides pasture and wildlife habitat, mainly for waterfowl (fig. 4). Capability unit IIw-2 irrigated.

Track Series

The Track series consists of somewhat poorly drained soils that formed in alluvium. These soils are on old alluvial plains, mainly in the vicinity south of Toppenish. The native vegetation is principally water-tolerant grasses and sedges and cottonwood and willow trees. Elevations range from 700 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Ashue, Naches, Toppenish, and Weirman soils.

In a representative profile, the surface layer is dark-gray and gray loam about 8 inches thick. The upper part of the subsoil is gray loam about 8 inches thick. The lower part is gray very gravelly loam about 6 inches thick. It has a few prominent mottles. The substratum to a depth of 64 inches is grayish-brown very gravelly sand that has a few prominent mottles. The soil is calcareous throughout. It is moderately alkaline and strongly alkaline.

Most of the acreage of Track soils has been drained and is irrigated.

Track loam (Tr). This is the most extensive of the Track soils. Areas range from about 50 to 200 acres in size. In most places the slope is about 1 percent. A representative profile is about 100 feet south of Granger Road and 700 feet east of Track Road, SE1/4NE1/4 sec. 30, T. 10 N., R. 21 E., W.M.

A11-0 to 3 inches, dark-gray (10YR 4/1) loam, very dark gray (10YR 3/0) moist; weak, thin, platy structure; soft, friable, slightly sticky and slightly plastic; many roots; common fine pores; about 2 percent gravel; violent effervescence; moderately alkaline; abrupt, smooth boundary.

A12-3 to 8 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) moist; moderate, thin, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; common fine pores; about 2 percent gravel; violent effervescence; moderately alkaline; abrupt, smooth boundary.

B21-8 to 16 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) moist; moderate, medium, angular blocky structure; hard, friable, sticky and plastic; few roots; common fine pores; thin discontinuous clay films on ped; about 5 percent gravel; violent effervescence; moderately alkaline; abrupt, wavy boundary.

IIB22g-16 to 22 inches, gray (10YR 5/1) very gravelly loam, very dark grayish brown (10YR 3/2) moist; few, medium,



Figure 4.-Migratory ducks on Toppenish Creek. The soil is Toppenish silty clay loam.

prominent, yellowish-red (5YR 5/6) mottles; massive; hard, firm, sticky and plastic; few roots; few fine pores; thin discontinuous clay films surrounding gravel; about 55 percent gravel; strong effervescence; some disseminated and segregated lime; some gravel is lime coated on the lower side; strongly alkaline; abrupt, wavy boundary.

IIC1-22 to 64 inches, grayish-brown (10YR 5/2) very gravelly sand, very dark grayish brown (10YR 3/2) moist; few, medium, prominent, yellowish-red (5YR 5/6) mottles; single grained; loose; few fine roots; 70 percent gravel and cobblestones; water table at a depth of 46 inches; moderately alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It ranges from very fine sandy loam to silt loam. It is mildly alkaline to strongly alkaline. The B horizon has value of 4 or 5 dry and chroma of 1 or 2 moist or dry. The IIB and IIC horizons have value of 4 or 5 dry and 3 or 4 moist and chroma of 1 or 2 moist or dry. They are moderately alkaline to strongly alkaline. Depth to the very gravelly sand IIC1 horizon ranges from 15 to 30 inches.

Included with this soil in mapping are small areas of gravelly soils, a few gently sloping long and narrow areas that are old intermittent stream channels, and a few areas of saline-alkali soils. Also included are small areas of Ashue, Toppenish, Weirman, and Zillah soils.

Generally the seasonal high water table is at a depth of 1 to 2 feet, but in places it is within a depth of 1 foot. Permeability is moderately slow. Runoff is very slow, and the hazard of erosion is none to slight. In irrigated areas the water table is held at a depth of 3 to more than 5 feet by deep open drains. The soil holds 4 to 5 inches of water that plants can use. Capability unit IIIw-1 irrigated.

Track gravelly loam (Ts).-This soil is similar to Track loam, but the surface layer differs in texture and slopes range from 0 to 5 percent. The soil is on old alluvial gravel bars. Areas are small in extent and variable in shape. Included in

mapping are areas where the soil has been altered by deep tillage or deep cuts made during land leveling. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The soil holds 2 to 4 inches of water that plants can use. Capability unit IIIw-1 irrigated.

Track silty clay loam (Tt).-This soil is similar to Track loam, but the surface layer differs in texture. The soil is in low basins or depressional areas on alluvial plains. In most places the slope is less than 1 percent. Runoff is very slow, and the hazard of erosion is none to slight. The soil holds 4 to 5 inches of water that plants can use. Capability unit IIIw-1 irrigated.

Umapine Series

The Umapine series consists of deep, somewhat poorly drained, saline-alkali soils that formed in alluvium. These soils are on bottom land and low terraces. The native vegetation is principally black greasewood, inland saltgrass, and basin wildrye grass. Elevations range from 650 to 900 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel, Stanfield, and Warden soils.

In a representative profile, the surface layer is light brownish-gray silt loam about 5 inches thick. It is very strongly alkaline. The substratum is light brownish-gray, light-gray, and grayish-brown silt loam to a depth of 60 inches. It is very strongly alkaline to mildly alkaline.

Some areas of Umapine soils have been drained and are irrigated (fig. 5).

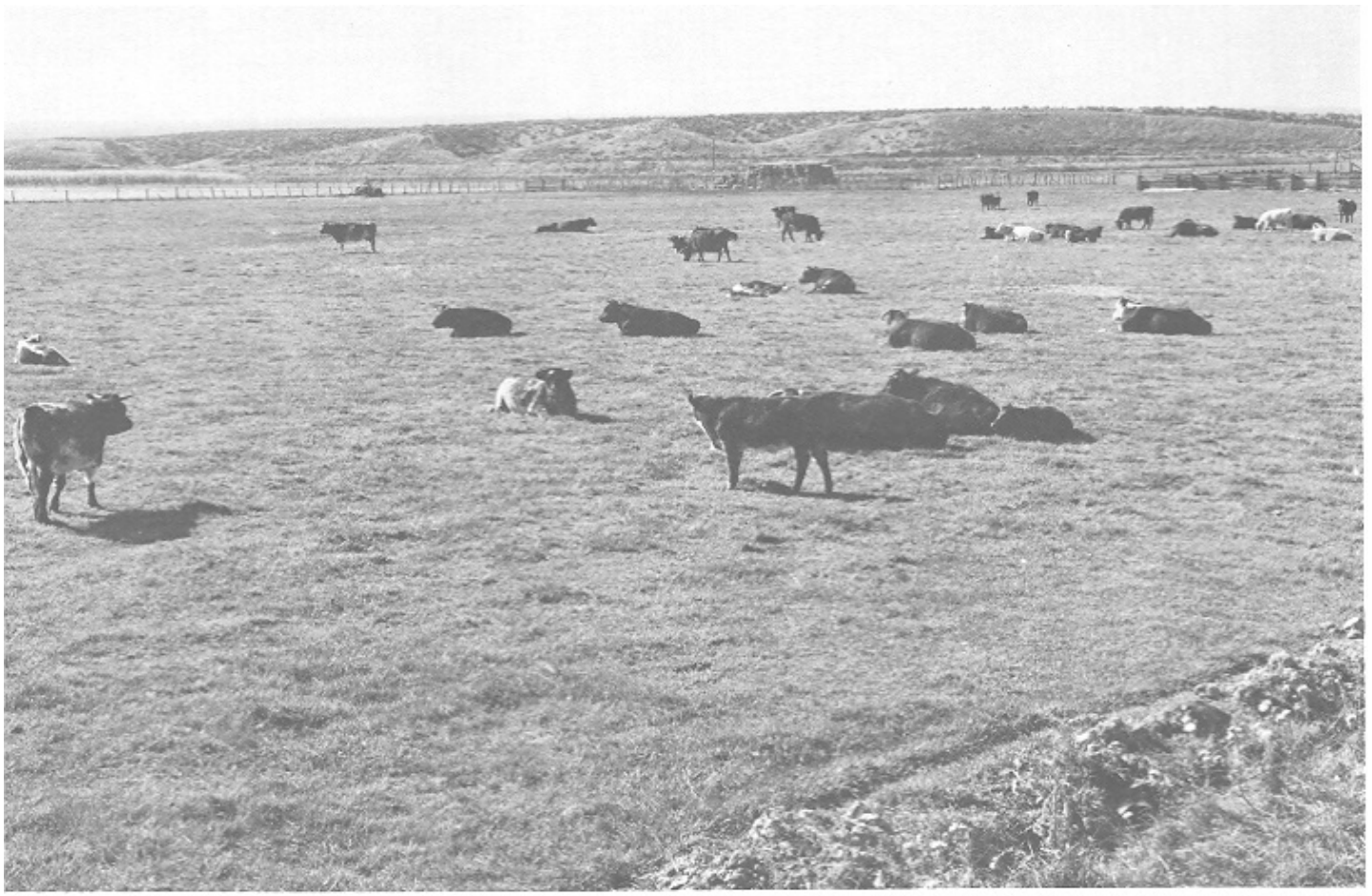


Figure 5.-Cattle grazing an irrigated pasture on Umapine silt loam. The soil in the background is nonirrigated Warden silt loam.

Umapine silt loam (Um).-In most areas this soil has slopes of about 1 percent. A representative profile is about 1,980 feet south of Jensen Road and 300 feet west of U.S. Highway No. 97, SW1/4NE1/4 sec. 28, T. 10 N., R. 20 E., W.M.

- A1-0 to 5 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; weak, thin, platy structure; soft, friable, slightly plastic; many roots; many fine pores; violent effervescence; very strongly alkaline; abrupt, smooth boundary.
- C1-5 to 22 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; soft, friable, slightly plastic; common roots; many fine pores; violent effervescence; very strongly alkaline; abrupt, wavy boundary.
- C2-22 to 29 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; hard, firm, slightly sticky and slightly plastic; common roots; many fine pores; weakly cemented concretions that range from to 7 inches in diameter; violent effervescence; very strongly alkaline; abrupt, broken boundary.
- C3ca-29 to 40 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; common, medium, faint mottles; massive; soft, friable, slightly sticky and slightly plastic; few roots; many fine pores; disseminated and segregated lime; violent effervescence; moderately alkaline; abrupt, wavy boundary.
- C4ca-40 to 46 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; massive; soft,

friable, slightly sticky and slightly plastic; few roots; many fine pores; violent effervescence; moderately alkaline; abrupt, wavy boundary.

C5-46 to 60 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; massive; soft, friable, slightly sticky and slightly plastic; few roots; many fine pores; mildly alkaline.

The A1 horizon has value of 5 or 6 dry and 3 or 4 moist and chroma of 2 or 3. It has a granular, thin, platy or blocky structure. The C1 and C2 horizons have value of 6 or 7 dry and 4 or 5 moist and chroma of 2 or 3. The Cca horizon has value of 5 through 7 dry and 3 through 5 moist and chroma of 2 or 3. In places, the C horizon is gravelly at a depth of more than 40 inches.

Included with this soil in mapping are small areas of Esquatzel, Stanfield, Toppenish, and Warden soils. Also included are areas of soils that are leached of excess salts, small areas of well-drained soils, small areas of poorly drained soils, small areas where slopes are as much as 5 percent, and small areas of soils that have a sandy loam surface layer.

Generally the seasonal high water table fluctuates between depths of 2 and 5 feet, but in places it is within a depth of 2 feet. In cultivated and irrigated areas the water table is held at a depth of 3 to more than 5 feet by deep drains. Permeability is moderate. Runoff is slow to ponded, and the hazard of erosion is slight. The soil holds 6 to 12 inches of water that plants can use. Capability unit IIw-1 irrigated.

Wahtum Series

The Wahtum series consists of deep, somewhat poorly drained, saline-alkali soils that formed in old alluvium. They are on low alluvial terraces and alluvial fans. Slopes are 0 to 5 percent. The native vegetation is principally black greasewood, big sagebrush, inland saltgrass, and basin wildrye. Elevations range from 350 to 1,000 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 43° to 52° F., and the frost-free season is 130 to 130 days. These soils are associated with Ahtanum, Kittitas, Onyx, and Simcoe soils.

In a representative profile, the surface layer is grayish-brown loam about 9 inches thick. The subsoil is dark-brown and brown clay or heavy silty clay loam about 11 inches thick. The upper part of the substratum is weakly cemented, brown silt loam about 4 inches thick. The lower part is stratified, grayish-brown sandy loam and very gravelly sandy loam to a depth of 60 inches.

A few areas of Wahtum soils have been drained and are irrigated.

Wahtum loam, 0 to 2 percent slopes (WaA).-This soil is on low alluvial terraces and alluvial fans, mainly in the Medicine Creek area. A representative profile is about 2,600 feet west of Hinman Road and 1,000 feet south of Progress Road, SW1/4NW1/4NE1/4 sec. 29, T. 11 N., R. 17 E., W.M.

A11-0 to 2 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak, thin, platy structure that parts to moderate, fine, granular structure; soft, very friable, slightly sticky and slightly plastic; many fine roots; common fine pores; moderately alkaline; abrupt, smooth boundary.

A12-2 to 9 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; weak, thick, platy structure that parts to weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; abrupt, wavy boundary.

B21t-9 to 14 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) moist; strong, medium, prismatic and columnar structure; very hard, firm, sticky and plastic; common roots; common fine pores; moderately alkaline; abrupt, wavy boundary.

B22t-14 to 20 inches, brown (10YR 5/3) heavy silty clay loam, dark brown (10YR 3/3) moist; massive; very hard, firm, sticky and plastic; few fine roots; common fine pores; weakly cemented concretions; strong effervescence on lime veins that coat concretions; moderately alkaline; abrupt, wavy boundary.

C1casim-20 to 24 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; massive; very hard, firm; few fine roots; common fine pores; weakly cemented; violent effervescence; light-gray (10YR 7/2) mycelial lime and lime coatings on embedded concretions; strongly alkaline; gradual, wavy boundary.

C2-24 to 46 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR, 3/2) moist; massive; soft, very friable, slightly plastic; few fine roots; violent effervescence; strongly alkaline; gradual, wavy boundary.

IIC3-46 to 60 inches, grayish-brown (10YR 5/2) very gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; massive; loose; 75 percent gravel and cobbles; violent effervescence; lime-silica coatings on much of the gravel; strongly alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It is loam, very fine sandy loam, or silt loam. It ranges from moderately alkaline to very strongly alkaline. The B horizon has value of 4 or 5. It ranges from heavy silty clay loam to clay. It is normally about 10 inches thick, but ranges from 5 to 20 inches. The structure from a depth of 2 to 6 inches is prismatic or columnar. Reaction ranges from moderately alkaline to very strongly alkaline. The C horizon ranges from weakly cemented to

indurated. The cementing agents are iron, silica, and lime. The solum is generally underlain by stratified alluvium, but in places it is underlain by basalt bedrock or material weathered from the Ellensburg Formation.

Included with this soil in mapping are small areas of Kittitas, Onyx, Simcoe, Stanfield, and White Swan soils and a few areas of poorly drained soils.

Generally the seasonal high water table fluctuates between depths of 2 and 5 feet, but in places it is within a depth of 2 feet. During the irrigation season the water table is held at a depth of 3 to more than 5 feet by deep drains. Permeability is very slow. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 5 to 9 inches of water that plants can use. Capability unit IVw-1 irrigated.

Wahtum loam, 2 to 5 percent slopes (WaB).-Except for slope, this soil is similar to Wahtum loam, 0 to 2 percent slopes. Included in mapping are small areas of moderately well drained soils and some areas where the soils are ponded. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IVw-1 irrigated.

Wahtum Series, Dark Variant

The Wahtum dark variant consists of deep, well-drained, saline-alkali soils that formed in old alluvium. These soils are on low terraces. Slopes are 0 to 5 percent. The native vegetation is principally black greasewood and big sagebrush. Elevations range from 700 to 850 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Umapine and Warden soils.

In a representative profile, the surface layer is gray and dark-gray silt loam about 5 inches thick. The subsoil is about 26 inches thick. The upper 3 inches of the subsoil is dark-gray clay loam, the next 14 inches is grayish-brown silty clay, and the lower 9 inches is grayish-brown silty clay loam. The substratum is light brownish-gray and light-gray, stratified silt loam and clay loam to a depth of 66 inches. A few areas of the Wahtum dark variant are irrigated.

Wahtum loam, dark variant (Wd).-This soil is south of Toppenish Creek, mainly on the low terraces of Toppenish Ridge. In most areas the slope is about 1 percent, but in a few small areas it is as much as 5 percent. A representative profile is about seven-tenths of a mile east of the intersection of Pumphouse Road and U.S. Highway No. 97, NE1/4SE1/4 sec. 33, T. 10 N., R. 20 E., W.M.

A11-0 to 3 inches, gray (10YR 5/1) loam, black (10YR 2/1) moist; moderate, thin, platy structure; soft, friable, slightly sticky and slightly plastic; few roots; strongly vesicular; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12-3 to 5 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) moist; weak, thin, platy structure; soft, friable, slightly sticky and slightly plastic; few roots; few fine pores; moderately alkaline; abrupt, smooth boundary.

B1ca-5 to 8 inches, dark-gray (10YR 4/1) clay loam, black (10YR 2/1) moist; strong, fine, granular structure; individual granules are slightly hard, but the horizon entity is soft, friable, sticky and plastic; few roots; few fine pores; strong effervescence; strongly alkaline; abrupt, smooth boundary.

B21tca-8 to 22 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 3/2) moist; moderate, medium, prismatic structure with dark gray (10YR 4/1) coatings on peds; hard, firm, very sticky and very plastic; common roots; common fine pores; some disseminated and mycelial lime; violent effervescence; very strongly alkaline; gradual, wavy boundary.

B22ca-22 to 31 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; massive; hard, firm, sticky and plastic; few roots; common fine pores; some disseminated and mycelial lime; violent effervescence; moderately alkaline; gradual, wavy boundary.

C1ca-31 to 45 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; hard, friable, slightly sticky and slightly plastic; few roots; common fine pores and few coarse pores; some disseminated and mycelial lime; violent effervescence; moderately alkaline.

IIC2-45 to 52 inches, light-gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; massive; slightly hard, friable; common fine pores; largely volcanic ash; mildly alkaline; abrupt, smooth boundary.

IIIC3-52 to 66 inches, light brownish-gray (10Y R 6/2) clay loam, dark grayish brown (10YR 4/2) moist; massive; hard, friable, sticky and plastic; few fine and coarse pores; mildly alkaline.

The A horizon ranges from 3 to 12 inches in thickness. It ranges from mildly alkaline to strongly alkaline. In places a layer of volcanic ash is between the A and B horizon. The IIC2 volcanic ash layer is lacking in places.

Included with this soil in mapping are small areas of Umupine and Warden soils.

Permeability is very slow. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 8 to 13 inches of water that plants can use. Capability unit IVs-1.

Warden Series

The Warden series consists of deep, well-drained soils that formed in a mantle of wind-laid material and underlying lake sediment. These soils are on uplands. Slopes are 0 to 30 percent. The native vegetation is principally big sagebrush, rabbitbrush, and bunchgrasses. Elevations range from 650 to 1,000 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel and Shano soils.

In a representative profile, the surface layer is grayish-brown silt loam about 12 inches thick. The subsoil is grayish-brown silt loam about 10 inches thick. The substratum is light brownish-gray and light-gray, weakly stratified silt loam to a depth of 62 inches. It is calcareous.

Most of the acreage of Warden soils is irrigated.

Warden silt loam, 0 to 2 percent slopes (WfA).-This soil is on uplands that begin at elevations slightly higher than the alluvial plains. In most areas the slope is about 1 percent. A representative profile is about 200 feet north of McDonald Road and 2,100 feet east of Bench Road, SE1/4SW1/4 sec. 32, T. 11 N., R. 18 E., W.M.

Ap1-0 to 4 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

Ap2-4 to 12 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

B2-12 to 22 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; abrupt, wavy boundary.

C1ca-22 to 44 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common

roots; common fine pores; violent effervescence; moderately alkaline; gradual, wavy boundary.

C2ca-44 to 62 inches, light-gray (2.5Y 7/2) silt loam, dark grayish brown (2.5Y 4/2) moist; massive and laminated; hard, firm, slightly sticky and slightly plastic; few roots; few fine pores; disseminated and segregated mycelial lime; violent effervescence; moderately alkaline.

The A and B horizons have value of 5 or 6 dry and 3 or 4 moist and chroma of 2 or 3. The C horizon has value of 6 or 7 dry and hue of 2.5Y or 10YR. In places, it is laminated silt loam stratified with fine sandy loam that is massive or single grained. Depth to free lime ranges from about 18 to 32 inches.

Included with this soil in mapping are small areas of Esquatzel, Shano, and White Swan soils. Also included are a few areas of saline-alkali soils and a few areas of somewhat poorly drained soils.

Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. The soil holds 10 to 13 inches of water that plants can use.

In areas that have been leveled and prepared for irrigation, the original horizons have been altered sufficiently to destroy their normal sequence. In many places the leveled soils are calcareous at the surface. In a few places leveling cuts in excess of 5 feet have exposed old lake sediments. Capability unit I-1 irrigated.

Warden silt loam 2 to 5 percent slopes (WfB).-Except for slope, this soil is similar to Warden silt loam, 0 to 2 percent slopes. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IIe-1 irrigated.

Warden silt loam, 5 to 8 percent slopes (WfC).-Except for slope, this soil is similar to Warden silt loam, 0 to 2 percent slopes. Runoff is medium, and the hazard of erosion is moderate. Capability unit IIIe-1 irrigated.

Warden silt loam, 8 to 15 percent slopes (WfD).-This soil is similar to Warden silt loam, 0 to 2 percent slopes, but differs in slope and in depth to the substratum. On south exposures the depth is 10 to 20 inches and on north exposures 20 to 35 inches. Included in mapping are a few small areas where the surface layer is fine sandy loam.

Runoff is rapid, and the hazard of erosion is severe. In places gullies have formed. Capability unit IVe-3 irrigated.

Warden silt loam, 15 to 30 percent slopes (WfE).This soil is similar to Warden silt loam, 0 to 2 percent slopes, but differs in slope and in depth to the substratum. On south exposures the depth is 10 to 20 inches and on north exposures 20 to 35 inches.

Runoff is very rapid, and the hazard of erosion is very severe. In places erosion has removed most of the original surface layer and formed deep gullies. Most areas are long and narrow and are between the alluvial flood plains and the gently sloping terraces. Capability unit VIe-1 irrigated.

Warden fine sandy loam, 0 to 2 percent slopes (WeA).-This soil is similar to Warden silt loam, 0 to 2 percent slopes, but the surface layer differs in texture. Runoff is slow, and the hazard of erosion is slight. The hazard of soil blowing is slight where the soil is bare of vegetation. Capability unit I-1 irrigated.

Warden fine sandy loam, 2 to 5 percent slopes (WeB).-This soil is similar to Warden silt loam, 2 to 5 percent slopes, but the surface layer differs in texture. Runoff is slow to medium, and the hazard of water erosion is slight to moderate. The hazard of soil blowing is slight where the soil is bare of vegetation. Capability unit IIe-1 irrigated.

Warden fine sandy loam, 5 to 8 percent slopes (WeC).-This soil is similar to Warden silt loam, 5 to 8 percent slopes, but the surface layer differs in texture. Runoff

is medium, and the hazard of water erosion is moderate. The hazard of soil blowing is slight where the soil is bare of vegetation. Capability unit IIIe-1 irrigated.

Weirman Series

The Weirman series consists of deep, somewhat excessively drained soils that are underlain by gravel. These soils formed in recent alluvium derived mostly from basalt. They are on low alluvial plains. Most of the acreage is dissected by perennial streams or old marshy stream channels. The native vegetation is mainly big sagebrush and cheatgrass. Cottonwood, willow, and alder trees are in areas adjacent to the main stream channels. Elevations range from 650 to 950 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Ashue, Naches, and Zillah soils.

In a representative profile, the surface layer is grayish-brown fine sandy loam about 9 inches thick. The substratum is brown loamy fine sand to a depth of about 20 inches and grayish-brown very gravelly loamy sand to a depth of 60 inches. These soils are neutral throughout.

Most of the acreage of Weirman soils is irrigated.

Weirman fine sandy loam, 0 to 2 percent slopes (WoA). This soil is on alluvial flood plains adjacent to the Yakima River. In most places the slope is about 1 percent. A representative profile is about 150 feet southwest of the intersection of Brooks and Weirman Roads, NE1/4NE1/4 sec. 30, T. 11 N., R. 20 E., W.M.

- Ap1-0 to 3 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, fine, granular structure; soft, very friable; many roots; neutral; abrupt, smooth boundary.
- Ap2-3 to 9 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; massive; soft, very friable; many fine roots, common fine pores; neutral; abrupt, smooth boundary.
- C1-9 to 20 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) moist; single grained; loose; many roots; common fine pores; neutral; gradual, wavy boundary.
- IIC2-20 to 43 inches, grayish-brown (10YR 5/2) very gravelly loamy sand, dark grayish brown (10YR 4/2) moist; single grained; loose; few roots; few fine pores; 75 percent gravel and cobbles; neutral; gradual, wavy boundary.
- IIC3-43 to 60 inches, grayish-brown (10YR 5/2) very gravelly loamy sand, dark grayish brown (10YR 4/2) moist; common, medium, prominent, yellowish-red (5YR 4/6) mottles; single grained; loose; 75 percent gravel and cobbles; few roots; neutral.

The A horizon ranges from fine sandy loam to sandy loam in texture and from 5 to 9 inches in thickness. The C1 horizon ranges from loam to loamy fine sand, and it is gravelly in places. It ranges from 6 to 20 inches in thickness. The IIC horizon ranges from very gravelly loamy sand to gravel. In many places the IIC 3 horizon is not mottled.

Included with this soil in mapping are small areas of Zillah, Ashue, and Track soils and a few areas of saline-alkali soils.

During the irrigation season the water table is at a depth of 3 to 5 feet in places. Permeability is very rapid. Runoff is slow, and the hazard of erosion is slight. The soil holds 2 to 5 inches of water that plants can use. Capability unit IIIs-1 irrigated.

Weirman fine sandy loam, 2 to 5 percent slopes (WoB). Except for slope, this soil is similar to Weirman fine sandy loam, 0 to 2 percent slopes. Most areas are somewhat undulating and in places include intermittent stream channels and small gravelly areas. Runoff is slow to medium,

and the hazard of erosion is slight to moderate. Capability unit IVe-1 irrigated.

Weirman sandy loam (Wm). This soil is similar to Weirman fine sandy loam, 0 to 2 percent slopes, but the surface layer differs in texture and the soil is dissected by stream channels. Areas adjacent to the Yakima River or its tributaries are subject to annual flooding. The old channel areas at some distance from the perennial stream channels are subject to a high water table during the growing season as a result of irrigation. Many of the old channel bottoms are similar to the poorly drained Zillah soil. Runoff is slow, and the hazard of erosion is slight. Capability unit VIw-1 nonirrigated.

Weirman gravelly sandy loam (Wn). This soil is similar to Weirman fine sandy loam, 0 to 2 percent slopes, but the surface layer and upper part of the substratum differ in texture and the slope ranges from 0 to 5 percent. Included in mapping are some areas where the soil is cobbly or very gravelly. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IVs-2 irrigated.

Weirman silt loam (Wr). This soil is similar to Weirman fine sandy loam, 0 to 2 percent slopes, but the upper 6 to 14 inches differs in texture. Most areas are between Wapato and the Yakima River and extend north and south parallel to the river. The soil is associated with Zillah soils. Runoff is slow, and the hazard of erosion is slight. The soil holds 3 to 5 inches of water that plants can use. Capability unit IIs-1 irrigated.

White Swan Series

The White Swan series consists of deep, well-drained, saline-alkali soils that formed in a thin mantle of loess over thick lake deposits. These soils are on terraces mainly in the vicinity of White Swan. Slopes are 0 to 8 percent. The native vegetation is principally inland saltgrass, black greasewood, basin wildrye, and big sagebrush. Elevations range from 850 to 1,050 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel, Kittitas, and Warden soils.

In a representative profile, the surface layer is mildly alkaline, grayish-brown silt loam about 3 inches thick. The upper 8 inches of the subsoil is moderately alkaline, grayish-brown silty clay loam. The lower 9 inches is calcareous, strongly alkaline, pale-brown silty clay loam. The substratum is laminated, light brownish-gray silt loam to a depth of 60 inches. It is calcareous and strongly alkaline.

Some of the acreage of White Swan soils irrigated.

White Swan silt loam, 0 to 2 percent slopes (WsA). This soil is mainly on low terraces. Slopes are dominantly about 1 percent. A representative profile is about 1.5 miles west of Shaker Road and 50 feet north of Fort Road, SE1/4SW1/4 sec. 4, T. 10 N., R. 17 E., W.M.

- A1-0 to 3 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak, thick, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; many fine vesicular pores; mildly alkaline; abrupt, smooth boundary.
- B21t-3 to 11 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; strong, medium, prismatic structure; very hard, firm, sticky and plastic; common roots, none or few roots inside peds, but in places roots matted on ped interfaces; common fine pores; medium continuous clay films on peds; moderately alkaline; gradual, wavy boundary.

B22ta-11 to 20 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; massive; very hard, firm, sticky and plastic; few roots; few fine pores; violent effervescence; few flecks of disseminated lime; very strongly alkaline; gradual, wavy boundary.

Cca-20 to 60 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; massive; laminar and weakly stratified; slightly hard, firm, layers very firm in place but friable once disturbed, slightly sticky and slightly plastic; few roots; common fine pores; violent effervescence; disseminated and segregated mycelial lime; strongly alkaline.

The A horizon has value of 5 or 6 dry and 3 or 4 moist. It is silt loam or very fine sandy loam and is mildly alkaline to strongly alkaline. The B horizon has value of 5 or 6 dry and 4 or 5 moist, chroma of 2 or 3 dry or moist, and hue of 2.5Y or 10YR. It is silty clay loam, silty clay, or clay and is moderately alkaline to very strongly alkaline. The Cca horizon has value of 6 or 7 dry, chroma of 2 or 3, and hue of 10YR or 2.5Y. It is silt loam and has thin layers of very fine sandy loam or fine sandy loam. It is moderately alkaline or strongly alkaline.

Included with this soil in mapping are small areas of Kittitas, Wahtum, and Warden soils. Permeability is slow. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 8 to 10 inches of water that plants can use. Capability unit IVs-1 irrigated.

White Swan silt loam, 2 to 5 percent slopes (WsB).-Except for slope, this soil is similar to White Swan silt loam, 0 to 2 percent slopes. Runoff is slow to medium, and the hazard of erosion is slight to moderate. Capability unit IVs-1 irrigated.

White Swan silt loam, 5 to 8 percent slopes (WsC).-Except for slope, this soil is similar to White Swan silt loam, 0 to 2 percent slopes. Runoff is medium, and the hazard of erosion is moderate. Capability unit IVs-1 irrigated.

Yakima Series

The Yakima series consists of deep, well-drained soils that formed in mixed alluvium. These soils are underlain by very gravelly coarse sand at a depth of 20 to 40 inches. They are on alluvial plains. Slopes are 0 to 3 percent. The native vegetation is principally big sagebrush, bitterbrush, and annual grasses. Elevations range from 700 to 1,200 feet. The mean annual precipitation is 6 to 9 inches, the mean annual temperature is 47° to 51° F., and the frost-free season is 120 to 170 days. These soils are associated with Logy, Onyx, and Simcoe soils.

In a representative profile, the surface layer is dark grayish-brown silt loam about 14 inches thick. The subsoil is dark-brown silt loam about 10 inches thick. The upper part of the substratum is weakly stratified gravelly silt loam to a depth of 35 inches, and the lower part is coarse sand to a depth of 60 inches. It becomes more gravelly with increasing depth.

Most of the acreage of Yakima soils is irrigated.

Yakima silt loam (Ya).-This soil is on the flood plain south and southwest of White Swan, NW1/4 sec. 8, T. 10 N., R. 17 E. In most areas the slope is about 2 percent.

A11-0 to 2 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; soft, friable, slightly sticky and slightly plastic; many roots; common fine pores; neutral; abrupt, smooth boundary.

A12-2 to 14 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR, 2/2) moist; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; gradual, wavy boundary.

B2-14 to 24 inches, dark-brown (10YR 4/3) silt loam, very dark grayish brown (10YR 3/2) moist; weak, coarse, prismatic structure; soft, friable, slightly sticky and slightly plastic; common roots; common fine pores; mildly alkaline; gradual, wavy boundary.

C1-24 to 35 inches, dark-brown (10YR 4/3) gravelly silt loam, dark brown (10YR 3/3) moist; massive; soft, friable, slightly sticky and slightly plastic; few fine pores; 40 percent gravel and cobbles; mildly alkaline; abrupt, wavy boundary.

IIC2-35 to 60 inches, dark-brown (10YR, 4/3) very gravelly coarse sand, very dark grayish brown (10YR 3/2) moist; single grained; loose; few roots; 70 percent gravel and cobbles; mildly alkaline.

The A horizon has value of 2 through 5 dry and 2 or 3 moist and chroma of 1 or 2. The B horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 2 or 3. It has weak, coarse, prismatic or weak, subangular blocky structure. The gravel content ranges from 0 to 5 percent. The C horizon is stratified and is 50 to 90 percent gravel and cobbles. The percentage increases with increasing depth.

Included with this soil in mapping are small areas of Logy and Onyx soils and a few areas where the soil is gravelly and stony.

In places the water table is at a depth of 3 to 5 feet during the irrigation season. Permeability is moderate above the very gravelly coarse sand substratum and very rapid in the very gravelly coarse sand. Runoff is slow, and the hazard of erosion is slight. The soil holds 6 to 8 inches of water that plants can use. Capability unit IIs-1 irrigated.

Yost Series

The Yost series consists of deep, somewhat poorly drained soils that formed in alluvium deposited in lakes or in ponded areas. These soils are on nearly level bottom land or in basins on the flood plain. Elevation is about 800 feet. The native vegetation is principally cattails, sedges, and rushes. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 48° to 52° F., and the frost-free season is 130 to 180 days. These soils are associated with Ahtanum, Kittitas, and Toppenish soils.

In a representative profile, the surface layer is gray clay about 41 inches thick. The substratum is light-gray clay to a depth of 62 inches.

Most of the acreage of Yost soils has been drained and is irrigated.

Yost clay (Yo).-This soil is mostly on bottom land or in basins on the flood plain southeast of Brownstown. A representative profile is about 50 feet north of McDonald Road and 4,200 feet east of Bench Road, SW1/4SE1/4SE1/4 sec. 32, T. 11 N., R. 18 E., W.M.

Ap-0 to 10 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) moist; strong, fine, angular blocky structure that parts to strong, fine and medium, granular structure; very hard, firm, very sticky and very plastic; many roots to 2 inches and common roots below 2 inches; few fine pores; wedge-shaped peds that have pronounced slickensides; mildly alkaline; gradual, smooth boundary.

A12-10 to 21 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) moist; moderate, medium, angular blocky structure; very hard, firm, very sticky and very plastic; few roots; wedge-shaped peds that have long axis tilted 10 to 60 degrees from horizontal; distinct slickensides on peds; slight effervescence; moderately alkaline; gradual, wavy boundary.

A13-21 to 41 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) moist; moderate, medium, angular blocky structure; many distinct wedge-shaped peds that have long axis tilted 10 to 60 degrees from horizontal; distinct slickensides on peds; very hard, firm, very sticky and very plastic; few roots; moderately alkaline; gradual, wavy boundary.

C-41 to 62 inches, light-gray (10YR 6/1) clay, dark gray (10YR 4/1) moist; massive; very hard, firm, very sticky and very plastic; few roots to a depth of 50 inches; mildly alkaline.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It ranges from 20 to more than 40 inches in thickness. The clay content ranges from 50 to 65 percent between depths of 10 and 40 inches. The clay fraction is dominated by montmorillonite. In most areas under irrigation the soils are wet or moist at all times. In areas not irrigated they have cracks 0.4 inch to 2 inches wide and 27 to 39 inches deep that open and close once each year.

Included with this soil in mapping are small areas of Kittitas and Toppenish soils, a few small areas of soils that are strongly alkaline, and a few areas of poorly drained soils. Generally the seasonal high water table is at a depth of 1 to 2 feet, but in places it is within a depth of 1 foot. Permeability is very slow. Runoff is very slow to ponded, and the hazard of erosion is none to slight. The soil holds 8 to 10 inches of water that plants can use. Capability IIIw-2 irrigated.

Zillah Series

The Zillah series consists of deep, somewhat poorly drained soils that formed in recent alluvium deposited in ponded areas. These soils are on low alluvial plains. Slopes are 0 to 2 percent. The native vegetation is mainly willows, cottonwoods, sedges, and annual weeds. Elevations range from 600 to 750 feet. The mean annual precipitation is 6 to 9 inches, the mean annual air temperature is 47° to 51° F., and the frost-free season is 130 to 180 days. These soils are associated with Esquatzel, Naches, Onyx, and Weirman soils.

In a representative profile, the surface layer is grayish-brown silt loam about 19 inches thick. The substratum is light brownish-gray silt loam to a depth of 31 inches, gray silt loam that has thin lenses of loamy sand to a depth of 51 inches, and gray loamy sand to a depth of 60 inches.

A few areas of Zillah soils have been drained and are irrigated.

Zillah silt loam (Zh).-This soil is in low alluvial areas mainly adjacent to the Yakima River. In most places the slope is about 1 percent. A representative profile is about 1,500 feet west of Winnier Road and 4,000 feet north of State Route 22, SE1/4SW1/4NE1/4 sec. 20, T. 9 N., R. 22 E., W. M.

A11-0 to 2 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak, medium, platy structure that parts to weak, fine and medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; common fine pores; neutral; abrupt, smooth boundary.

A12-2 to 19 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; many, medium, distinct, dark-brown (7.5YR 4/4) mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; neutral; gradual, wavy boundary.

C1-19 to 31 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; many, medium, distinct, dark-brown (7.5YR 4/4) mottles; massive; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; common fine pores; neutral; gradual, wavy boundary.

C2-31 to 51 inches, gray (10YR 6/1) silt loam that has lenses of loamy sand 1/2 to 2 inches thick, dark gray (10YR 4/1) moist; many, coarse, prominent, dusky-red (2.5YR 3/2) and dark-brown (7.5YR 3/4) mottles; massive; soft; few roots; neutral; abrupt, wavy boundary.

IIC3-51 to 60 inches, gray (10YR 6/1) loamy sand, dark gray (10YR 4/1) moist; many, coarse, prominent mottles,

dusky red (2.5YR 3/2) and dark brown (7.5YR 3/4) moist; massive; loose; few fine roots; neutral.

The A horizon has value of 4 or 5 dry and 2 or 3 moist and chroma of 1 or 2. It ranges from silt loam to very fine sandy loam. It is neutral to moderately alkaline. The C horizon has value of 5 or 6 dry and 3 or 4 moist and chroma of 1 or 2. It ranges from silt loam to very fine sandy loam stratified with loamy sand.

Included with this soil in mapping are small areas of Ashue, Esquatzel, Toppenish, and Weirman soils; a few small areas of soils that are very gravelly below a depth of 51 inches; and a few areas of poorly drained soils. Generally the seasonal high water table is at a depth of 1 to 2 feet, but in places it is within a depth of 1 foot. In drained and irrigated areas, the seasonal high water table can be lowered to a depth of 3 to 5 feet by deep drains. Permeability is moderate. Runoff is slow, and the hazard of erosion is slight. Some areas are subject to flooding, and in places streambank cutting occurs. The soil holds 9 to 12 inches of water that plants can use. Capability unit IIw-2 irrigated.

Zillah silt loam, channeled (Zn).-This soil is similar to Zillah silt loam, but it is more coarsely stratified and slopes range from 0 to 5 percent. The soil is dissected by intermittent and perennial stream channels. Included in mapping are small areas of Ashue, Onyx, and Weirman soils. Runoff is slow and the hazard of erosion is slight. Most areas of this soil are subject to flooding at least once a year. The native vegetation is principally willows, cottonwoods, wildrose, blackberries, and annual broadleaf weeds. Capability unit VIw-1 nonirrigated.

Use and Management of the Soils

This section explains the system of capability classification used by the Soil Conservation Service. It describes the capability units into which the soils of the survey area have been classified and shows estimated yields of irrigated crops. It also explains the use of the soils for windbreaks and gives information about soil characteristics significant in engineering.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, all kinds of soil are grouped at three levels, the capability class, the subclass, and the unit. These levels are defined in the paragraphs that follow.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for

practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife. (There are no class V soils in the Yakima Indian Reservation Irrigated Area.)

Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuitable for cultivation and restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial production of plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (There are no class VIII soils in the Yakima Indian Reservation Irrigated Area.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIe-6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

On the following pages the capability units in the Yakima Indian Reservation Irrigated Area are described and use and management of the soils is suggested.

The soil series represented in each unit are named, but this does not mean that all the soils of a given series are in

the unit. To find the unit in which a given soil has been placed, refer to the "Guide to Mapping Units" at the back of this survey.

Management by capability units

Certain practices basic to good soil management apply to all capability units. Fundamental among these is the use of a soil-conserving cropping system, which consists of the selection of a suitable crop rotation and management that supplements this rotation in maintaining productivity of the soil and in controlling wetness or erosion. The rotation most commonly used in the survey area is 1 year of corn, 2 years of sugar beets, and 3 years of alfalfa.

Maintaining and improving soil structure and the content of organic matter are important. Sources of organic matter are crop residue, barnyard manure, and sod crops. Regular additions of organic matter are ordinarily the most beneficial and are needed most if the rotation is intensive or the cultivation continuous.

Of the 222,930 acres in the survey area, about 190,000 acres is irrigated. The safe and uniform distribution of irrigation water is most important. For drilled crops, irrigation water is generally applied within borders by controlled flooding, corrugations, and sprinklers. Furrows and sprinklers are used for row crops. Care is required in selecting irrigation grades, length of runs, width between borders, frequency and time of applying water, and size of flow. Using irrigation water efficiently is essential in keeping to a minimum the loss of water through deep percolation and runoff and the loss of soil through erosion. Where needed and feasible, the soils should be leveled to a uniform grade. In some areas not leveled, irrigation should be across the slope or on the contour if water is applied in corrugations or furrows.

Drainage is needed on some soils to lower the water table. Both tile drains and open ditches are satisfactory.

The capability units in the Yakima Indian Reservation Irrigated Area are described on the following pages. The soils in any one unit are similar in the kind of management they require and in their response to that management.

CAPABILITY UNIT I-1 IRRIGATED

This unit consists of well-drained soils of the Esquatzel, Onyx, Shano, and Warden series. Slopes are 0 to 2 percent. These soils are more than 60 inches deep. Available water capacity is high, and permeability is moderate. Runoff is slow, and the hazard of erosion is slight. The frost-free season is 130 to 180 days.

These are the most productive and the least limited of any soils in the survey area. All climatically adapted crops that require good drainage do well. Among the irrigated crops grown are asparagus, corn, grapes, hops, mint, peas, sugar beets, tree fruits, and grasses and legumes for hay, pasture, and seed.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the crop; utilization of all crop residue to maintain and improve organic-matter content and soil structure; and timely and uniform application of the right amount of irrigation water. Corrugations, furrows, borders, controlled flooding, or sprinklers can be used for irrigating.

CAPABILITY UNIT IIe-1 IRRIGATED

This unit consists of well-drained soils of the Esquatzel, Naches, Onyx, Ritzville, Shano, Simcoe, and Warden series. Slopes are 2 to 5 percent. All but Naches and Simcoe soils are more than 60 inches deep. The average soil is 20 to 40 inches

deep over gravel, and the Simcoe soil is 30 to 40 inches deep over basalt bedrock or cemented gravel. Available water capacity is high in the soils more than 40 inches deep and moderately high in the rest. Permeability is moderate or moderately slow. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The frost-free season is 120 to 180 days.

All climatically adapted crops that require good drainage do well. Among the irrigated crops grown are asparagus, corn, grain, grapes, hops (fig. 6), mint, peas, sugar beets, tree fruits, and grasses and legumes for hay, pasture, and seed.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the crop; utilization of all crop residue to maintain and improve the organic-matter content and soil structure; rotation of crops; and timely and uniform application of the right amount of irrigation water. Corrugations, furrows, or sprinklers can be used for irrigating. The hazard of erosion can be minimized if runs are short or if irrigation furrows and corrugations are laid out across the slope and are held to a gradient of 2 percent or less. Land leveling should be closely checked in the soils that have a gravelly substratum. Shallow cuts are possible in selected areas.

CAPABILITY UNIT IIw-1 IRRIGATED

This unit consists of somewhat poorly drained saline and very strongly alkaline soils of the Ahtanum, Kittitas, and

Umapine series. Slopes are dominantly 0 to 2 percent, but range to 5 percent. Kittitas and Umapine soils are more than 60 inches deep. The Ahtanum soil is 20 to 40 inches deep over a lime-silica cemented hardpan. Available water capacity is high in the Kittitas soil and moderately high to high in Ahtanum and Umapine soils. The ability of plants to utilize water is affected by the degree to which excess salts have been removed. Permeability is moderate in Kittitas and Umapine soils. In the Ahtanum soil it is moderate above the hardpan and very slow in the pan. Runoff is dominantly slow to ponded, but ranges to medium. The hazard of erosion is dominantly none to slight. The frost-free season is 130 to 180 days.

If drained, freed of excessive salts, and irrigated, these soils are suited to asparagus, corn, peas, and sugar beets and to grasses and legumes for hay and pasture.

The management needs are drainage; leaching and the possible addition of such amendments as gypsum, sulfur, sulfuric acid, or ferric sulfate to facilitate leaching; application of fertilizer according to the needs of the crop; utilization of all crop residue to maintain and improve the organic-matter content and soil structure; rotation of crops; and timely and uniform application of the right amount of irrigation water. Furrows, corrugations, borders, flooding, or sprinklers can be used for irrigating. Border irrigation and flooding, however, are not suitable where slopes are 2 to 5 percent.



Figure 6.-Hops harvested early in September. The soil is Esquatzel silt loam.

CAPABILITY UNIT III-2 IRRIGATED

This unit consists of somewhat poorly drained soils of the Toppenish and Zillah series. Slopes are dominantly 0 to 2 percent, but range to 5 percent. These soils are more than 60 inches deep. Available water capacity is high, and permeability is moderate. Runoff is very slow or slow in most areas, but is medium in a few areas where slopes are steeper.

The hazard of erosion is none to slight in most areas, but is moderate in a few areas where slopes are steeper. The frost-free season is 130 to 180 days.

If drained and irrigated, these soils are suitable for asparagus, corn, grain, hops, mint, peas, sugar beets, and grasses and legumes for hay and pasture.

The management needs are drainage, application of fertilizer according to the needs of the crop, utilization of all crop residue to maintain and improve the organic-matter content and soil structure, rotation of crops, and timely and uniform application of the right amount of water. Furrows, corrugations, borders, flooding, or sprinklers can be used for irrigating. Border irrigation and flooding, however, are not suitable where slopes are 2 to 5 percent.

CAPABILITY UNIT II_s-1 IRRIGATED

This unit consists of well-drained to somewhat excessively drained soils of the Naches, Simcoe, Weirman, and Yakima series. Slopes are 0 to 2 percent. All but Simcoe soils are 20 to 40 inches deep over very gravelly material that extends to a depth of 60 inches or more. Simcoe soils are 30 to 40 inches deep over bedrock. Available water capacity is moderately high to high in Naches, Simcoe, and Yakima soils and low to moderate in the Weirman soil. Permeability is moderate or moderately slow. Runoff is slow, and the hazard of erosion is slight. The frost-free season is 120 to 180 days.

All climatically adapted crops that require good drainage do well. Among the irrigated crops grown are asparagus, corn, grapes, mint, peas, sugar beets, tree fruits, and grasses and legumes for hay and pasture.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the crop; rotation of crops; utilization of all crop residue to maintain the organic-matter content and soil structure; and timely and uniform application of the right amount of irrigation water. Corrugations, furrows, borders, controlled flooding, or sprinklers can be used for irrigating. Land leveling should be closely checked. Shallow cuts are possible in selected areas.

CAPABILITY UNIT III_e-1 IRRIGATED

This unit consists of well-drained soils of the Ritzville, Shano, Simcoe, and Warden series and the Ritzville series, gravelly subsoil variant. Slopes are 5 to 8 percent. Ritzville, Shano, and Warden soils are more than 60 inches deep. Simcoe soils are 30 to 40 inches deep over basalt bedrock or cemented gravel. Available water capacity is high in Ritzville, Shano, and Warden soils and is moderately high to high in Simcoe soils and the Ritzville variant. Permeability is moderate in Ritzville, Shano, and Warden soils and is moderately slow in Simcoe soils. Runoff is medium, and the hazard of erosion is moderate. The frost-free season is 130 to 180 days.

These soils are suited to small grain and perennial hay and pasture crops and to tree fruits and grapes if a cover crop can be established to control erosion.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the

crop; utilization of all crop residue to control erosion and improve organic-matter content; and use of cover crops in orchards and vineyards to help control erosion. Corrugations, furrows, or sprinklers can be used for irrigating. Corrugations and furrows should be laid out across the slope and held to a gradient of 2 percent or less.

CAPABILITY UNIT III_w-1 IRRIGATED

This unit consists of somewhat poorly drained soils of the Track series. Slopes are dominantly 0 to 2 percent, but range to 5 percent. These soils are 15 to 30 inches deep over very gravelly sand that extends to a depth of 60 inches or more. Available water capacity is low to moderate. Permeability is moderately slow. Runoff is very slow to slow, and the hazard of erosion is none to slight in most areas. Runoff is medium, and the hazard of erosion is moderate in a few areas where slopes are steeper. The frost-free season is 130 to 180 days.

If drained and irrigated, these soils are suited to sweet corn, field corn, small grain, peas, and sugar beets and to grasses and legumes for hay and pasture.

The management needs are drainage to keep the water table below the root zone of the crops; application of fertilizer according to the needs of the crop; utilization of crop residue to maintain organic-matter content and good soil structure; and timely and uniform application of irrigation water. Corrugations, furrows, borders, or sprinklers can be used for irrigating. Borders, however, are not suitable where slopes are 2 to 5 percent. Land leveling should be restricted. Shallow cuts are possible in selected areas.

CAPABILITY UNIT III-2 IRRIGATED

The one soil in this unit is Yost clay, a somewhat poorly drained soil more than 60 inches deep. Slopes are 0 to 2 percent. Available water capacity is high. Permeability is very slow. Runoff is ponded to very slow, and the hazard of erosion is none to slight. The frost-free season is 130 to 180 days.

If drained and irrigated, this soil is suited to corn and small grain and to grasses and legumes used for hay and pasture.

The management needs are drainage, application of fertilizer according to the needs of the crop, utilization of all crop residue to maintain and improve the organic-matter content and soil structure, rotation of crops, and timely and uniform application of the right amount of irrigation water. Corrugations, furrows, borders, or sprinklers can be used for irrigating.

CAPABILITY UNIT III_s-1 IRRIGATED

This unit consists of well-drained and somewhat excessively drained soils of the Ashue, Logy, and Weirman series. Slopes are 0 to 2 percent. These soils are 20 to 40 inches deep over very gravelly material that extends to a depth of 60 inches or more. Available water capacity is low to moderately high. Permeability is moderately slow to very rapid. Runoff is slow, and the hazard of erosion is slight. The frost-free season is 130 to 180 days.

If irrigated, these soils are suited to corn, small grain, grapes, tree fruits, and truck crops and to grasses and legumes for hay and pasture.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the crop, utilization of all crop residue to maintain and improve the organic-matter content, rotation of crops, and

timely and uniform application of the right amount of irrigation water. Corrugations, furrows, borders, and sprinklers can be used for irrigating. Land leveling should be closely checked for depth to the gravelly material. Shallow cuts are possible in selected areas.

CAPABILITY UNIT IVe-1 IRRIGATED

This unit consists of well-drained and somewhat excessively drained soils of the Ashue and Weirman series. Slopes are 2 to 5 percent. These soils are 15 to 30 inches deep over very gravelly sandy loam or loamy sand that extends to a depth of more than 60 inches. Available water capacity is low to moderate. Permeability is moderately slow in the Ashue soils and very rapid in the Weirman soils. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The frost-free season is 130 to 180 days.

These soils are suited to small grain and hay and pasture crops and to tree fruits and grapes if a cover crop can be established.

The management needs are application of fertilizer according to the needs of the crop; utilization of crop residue to maintain organic-matter content and good soil structure, and control of the flow of irrigation water to prevent soil erosion. These soils are best suited to sprinkler irrigation, but corrugations and furrows can be used if they are laid out across the slope and held to a gradient of 2 percent or less. Land leveling should be restricted. Shallow cuts are possible in selected areas.

CAPABILITY UNIT IVe-2 IRRIGATED

This unit consists of somewhat excessively drained soils of the Hezel and Quincy series. Slopes are 0 to 15 percent. These soils are sandy and are more than 60 inches deep. Available water capacity is moderately high to high. Permeability is moderate in the Hezel soils and rapid in the Quincy soils. Runoff ranges from very slow to medium, and the hazard of water erosion is none to moderate. The hazard of soil blowing is severe. The frost-free season is 130 to 180 days.

Where irrigated, these soils are suited to grasses and legumes for hay and pasture if small grain is grown as a cleanup crop between seedings.

The management needs are application of nitrogen, phosphate, and other fertilizer according to the needs of the crop; minimum tillage; utilization - of all crop residue to maintain the organic-matter content; smoothing; and frequent and uniform application of the right amount of irrigation water by sprinklers.

CAPABILITY UNIT IVe-3 IRRIGATED

This unit consists of well-drained soils of the Ritzville, Shano, and Warden series. Slopes are 8 to 15 percent. These soils are more than 40 inches deep. Available water capacity is high. Permeability is moderate. Runoff is rapid, and the hazard of erosion is severe. The frost-free season is 130 to 180 days.

These soils are suited to perennial grasses and legumes used for hay and pasture and to tree fruits and grapes if a cover crop can be established.

The management needs are application of fertilizer according to the needs of the crop, use of close-growing crops or cover crops in orchards, minimum tillage, utilization of all crop residue, and control of the application rate of irrigation water to prevent erosion. These soils are best suited to sprinkler irrigation.

CAPABILITY UNIT IVw-1 IRRIGATED

This unit consists of moderately well drained and somewhat poorly drained soils of the Fiander, Stanfield, and Wahtum series. Slopes are 0 to 5 percent. These soils are saline arid moderately alkaline to very strongly alkaline. Fiander and Wahtum soils are more than 60 inches deep. Stanfield soils are 20 to 40 inches deep over a silica-cemented hardpan. Available water capacity is low to high. Permeability is slow and very slow. Runoff is ponded to medium, and the hazard of water erosion is none to moderate. The hazard of soil blowing is moderate to severe on Fiander loamy fine sand and Stanfield sandy loam. The frost-free season is 130 to 180 days.

If leached, irrigated, and drained, these soils are suited to corn, small grain, and sugar beets and to grasses and legumes for hay and pasture.

The management needs are drainage; leaching and the possible addition of such amendments as gypsum, sulfur, sulfuric acid, or ferric sulfate to facilitate leaching; application of fertilizer according to the needs of the crops; utilization of all crop residue to maintain and improve the organic-matter content and soil structure; rotation of crops; and timely and uniform application of the right amount of irrigation water. Furrows, borders, flooding, or sprinklers can be used for irrigating. Borders and flooding, however, are not suitable where slopes are 2 to 5 percent.

CAPABILITY UNIT IVs-1 IRRIGATED

This unit consists of well-drained soils of the White Swan series and of the Wahtum series, dark variant. Slopes are dominantly 0 to 5 percent, but range to 8 percent. These soils are saline and moderately alkaline to very strongly alkaline. They are more than 60 inches deep. Available water capacity is high, and permeability is slow or very slow. Runoff is ponded to medium, and the hazard of water erosion is none to moderate. The frost-free season is 130 to 180 days.

Concentrated salts and slow or very slow permeability are the chief limitations (fig. 7). If leached and irrigated, these soils are suited to corn, small grain, and sugar beets and to grasses and legumes for hay and pasture.

The management needs are leaching and the possible addition of such amendments as gypsum, sulfur, sulfuric acid, or ferric sulfate to facilitate leaching; drainage to prevent buildup of a water table under irrigation; application of fertilizer according to the needs of the crop; utilization of all crop residue to maintain and improve the organic-matter content and soil structure; rotation of crops; and timely and uniform application of the right amount of irrigation water. Furrows, borders, flooding, or sprinklers can be used for irrigating, but borders and flooding are not suitable where slopes are 2 to 5 percent. Furrows should be laid out across the slope and held to a gradient of 2 percent or less.

CAPABILITY UNIT IVs-2 IRRIGATED

This unit consists of well-drained and somewhat excessively drained soils of the Ashue and Weirman series. Slopes are 0 to 5 percent. These soils are gravelly sandy loam and gravelly loam 10 to 20 inches deep over very gravelly loamy sand or sand. Available water capacity is low to moderate. Permeability is very rapid in the very gravelly layers. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The frost-free season is 130 to 180 days.

If irrigated, these soils are suited to grasses and legumes for pasture and hay and to tree fruits and grapes.



Figure 7.-Experimental deep plowing on White Swan silt loam disseminates concentrated salts.

The management needs are application of fertilizer according to the needs of the crop and utilization of crop residue and cover crops in vineyards and orchards to maintain organic-matter content. These soils are best suited to sprinkler irrigation. Furrows can be used if they are laid out on a 2 percent gradient. Land leveling should be restricted. Shallow cuts are possible in selected areas.

CAPABILITY UNIT VIe-1 IRRIGATED

This unit consists of well-drained soils of the Ritzville, Shano, and Warden series. Slopes are dominantly 15 to 30 percent, but in a small area they range to 65 percent. These soils are more than 60 inches deep. Available water capacity is high. Permeability is moderate. Runoff is very rapid, and the hazard of erosion is very severe. The frost-free season is 130 to 180 days. If irrigated, these soils are best suited to pasture or orchards and perennial cover crops.

The management needs are application of fertilizer according to the needs of the crop; use of legumes in pasture and in cover crop mixtures; limitation of tillage to the minimum necessary to establish pasture and orchard cover crops; and applying water by sprinklers no faster than it can infiltrate the soil.

CAPABILITY UNIT VIw-1 NONIRRIGATED

This unit consists of soils adjacent to perennial or intermittent streams that are subject to seasonal flooding or have

a high water table. These are soils of the Logy, Weirman, and Zillah series. Logy and Weirman soils are less than 20 inches deep over gravel. Zillah soils are more than 60 inches deep. The Logy soils are dry soon after the flood season. Available water capacity is low to high. Permeability is moderate to very rapid. Runoff is slow, and the hazard of erosion is slight. The frost-free season is 120 to 180 days.

These soils are best suited to grazing and wildlife. The native vegetation is bluebunch wheatgrass, basin wildrye, big bluegrass, willows, cottonwoods, and annual weeds in moist areas. Big sagebrush, rabbitbrush, and annual grasses grow in drier areas. The soils are better suited to grasses that tolerate flooding than to other plants.

CAPABILITY UNIT VIIs-1 NONIRRIGATED

The one soil in this unit, the well-drained Rock Creek very stony loam, 0 to 20 percent slopes, is only 10 to 20 inches deep over fractured basalt bedrock. Available water capacity is low. Permeability is moderately slow. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The frost-free season is 120 to 170 days.

This soil is too stony and too shallow for crops. It is best suited to grazing and wildlife. The native vegetation is mainly buckwheat, phlox, and Sandberg bluegrass. If the vegetation is in excellent condition, the total annual yields range from 200 to 300 pounds per acre.

Estimated Yields

Table 2 shows estimates of yields for some of the principal irrigated crops grown in the survey area. The estimates are based on the observation of soil scientists who surveyed the area and on information furnished by farmers, fertilizer establishments, food processors, and advisors from the Bureau of Indian Affairs and Soil Conservation Service familiar with the soils and the farming in the survey area. The estimates are averages for a period of years. In any given year, the yields of any crop can be more or less than the figure shown.

In order to obtain the yields shown in table 2, kinds and amounts of fertilizer are applied according to plant requirements as determined by soil tests, field trials, and experience. Other suggested management follows.

- For alfalfa hay-Plant adapted varieties; control weeds; use insecticides at the right time; manage water efficiently; harvest 4 cuttings per season.
- For asparagus-Control cutworms by chemicals; control weeds by cultivation, chemicals, and hand hoeing (deep cultivation damages the crowns); supervise closely during harvest; complete harvest about June 20; manage water efficiently.
- For corn-Plant crop when soil temperature and moisture conditions are right; control weeds by cultivation and herbicides; manage water efficiently; insure proper use and application of insecticides.
- For hops-Before establishing a new yard, plow down as much as 30 pounds of zinc in the form of zinc sulfate; use zinc foliage spray to correct zinc deficiency during growing season; early in spring remove excess shoots from root stock and remove all diseased parts of crowns; use insecticides and fungicides for disease control; manage water efficiently, removing all tail water.
- For mint-Prepare seedbed after harvest of a weed-free crop; obtain stolons from Verticillium wilt-free fields; control weeds by geese (1 goose per acre) and by mechanical means, two hoeings if needed; spray for twospotted mite; return all mint hay to the fields; manage irrigation water efficiently, removing all tail water.
- For sugar beets-Prepare a proper seedbed; follow mechanical thinning with hand thinning; control weeds by herbicides, mechanical cultivation, and hand hoeing where needed; manage irrigation water efficiently and if furrow irrigation is used, remove all tail water.
 - Available nitrogen in excess of 200 pounds per acre generally results in a reduction in the yield of sugar (sucrose) per acre.
- For winter wheat-Prepare good seedbed and sow seed by mid-November; if weed control is needed, spray with herbicide in spring; irrigate efficiently before plants are under stress.

Windbreak

Fields and farmsteads in the survey area commonly need protection from strong winds. Well-planned, well-maintained,

This section was prepared by LAWRENCE L. LENZ, forester, SCS, Yakima, Washington, assisted by JACK RASMUSSEN, soil scientist, SCS senior author.

and irrigated plantings of trees and shrubs provide protection for crops, reduce erosion, provide protection for livestock and buildings, and furnish food and cover for wildlife. Shrubs adapted to the area are caragana, bladder senna, blueleaf honeysuckle, lilac, multiflora rose, and southernwood. Intermediate trees adapted to the area are Russian-olive, Russian-mulberry, hawthorn, golden willow, blue spruce, and Rocky Mountain juniper. Tall trees adapted to the area are green ash, black locust, hybrid poplar, Lombardy poplar, Scotch pine, ponderosa pine, Austrian pine, Norway spruce, and Douglas-fir.

The suitability of shrubs and trees for windbreak plantings is governed largely by the salt and alkali content of the soil and the depth to the water table. Species that are most tolerant to a high salt or alkali content, such as in Ahtanum, Fiander, Kittitas, Stanfield, Umapine, and Wahtum dark variant soils, for example, are southernwood, Russian-olive, hybrid poplar, Lombardy poplar, and Rocky Mountain juniper. Species such as blue spruce and Douglas-fir are not suited to soils that have a high salt or alkali content. Species that are most tolerant to a high water table, as in the Ahtanum, Fiander, Kittitas, Toppenish, Track, Yost, and Zillah soils, are golden willow, hybrid poplar, and Lombardy poplar. Species that have a low tolerance to a high water table are bladder-senna, southernwood, ponderosa pine, and Rocky Mountain juniper.

The farmstead or feedlot windbreak is generally made up of three or more rows. The field windbreak is made up of one or more rows. In a multiple-row windbreak, dense fastgrowing shrubs are needed on the windward side, one or more rows of tall evergreen or deciduous trees in the middle rows, and one or more rows of evergreens on the leeward side.

In multiple-row plantings, caragana and Russian-olive are suitable shrubs for most soils in this survey area. Green ash and black locust are generally the preferred trees in the center rows where height is needed. Austrian pines or Scotch pines are commonly the preferred evergreen trees for windbreaks. Douglas-fir, Norway spruce, and Rocky Mountain juniper are all well adapted where sufficient moisture is provided. For the first year after planting, most evergreens require some protection from severe heat and wind. This can be provided by standing up a shingle or similar device on the south side of the tree. Other species suitable for multiple-row plantings are bladder-senna, blueleaf honeysuckle, lilac, multiflora rose, southernwood, hawthorn, ponderosa pine, Norway spruce, and blue spruce. All these species, with the exception of Norway spruce, are also suitable for two-row plantings.

Single-row plantings are generally made to provide field crops protection from soil blowing. One of the most commonly planted species is Lombardy poplar, which is fast growing and provides protection at an early age. Other species suitable for single-row plantings are caragana, multiflora rose, southernwood, Russian-olive, golden willow, hybrid poplar, and Douglas-fir.

Many factors have to be considered in deciding on the type of windbreak needed. Among these are the crops to be grown that need protection, the location of the windbreak, and the benefit to wildlife. Where fruit crops are grown and high wind is a problem, protection is needed against excessive water transpiration and fruit damage. A one-row planting is satisfactory. Lombardy poplar is suitable for one-row plantings because it grows fast and tall. Windbreaks should be planted where

planted where they do not interfere with irrigation tillage equipment.

Many secondary benefits are derived from a windbreak. One of the foremost is its use as wildlife habitat. Multiplerow windbreaks are a natural habitat for game birds as well as songbirds.

Such shrubs as caragana and bladder-senna and such trees as Russian-olive and black locust provide food and cover for wildlife.

Soils to be planted to windbreaks should be fall plowed and free of weeds before the seedlings are established. Shrubs and trees cannot compete with weeds and grass. Clean cultivation and irrigation are necessary to assure good survival. Protection is needed against livestock, poultry, and fire.

Use of the Soils in Engineering

This section is useful to those who need information about soils used as structural material or as foundations upon which structures are built. Among those who can benefit from this information are town and city managers, planning commissions, land developers, engineers, contractors, and farmers.

Among the soil properties that are most important in engineering are permeability, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage effluent and refuse.

Information in this section can be helpful to those who

1. Select potential residential, industrial, commercial, and recreational sites.
2. Evaluate alternative routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 3 and 4. These tables show, respectively, estimates of soil properties significant in engineering and interpretations for various engineering uses.

This information, along with the soil map for identification and the information in other sections, allows many interpretations other than those given in tables 3 and 4. It also can be used to make other useful maps. The information does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially small ones,

is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for engineering uses.

Some terms in this soil survey have special meaning in soil science that may be unfamiliar to engineers. The Glossary defines many of these terms.

Engineering classification

The two systems most commonly used in classifying samples of soils for engineering are the AASHO system (1) adopted by the American Association of State Highway Officials and the Unified system (7) used by the SCS engineers, Department of Defense, and others. Both systems are described in the PCA Soil Primer (2).

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system all soil material is classified in one of seven basic groups. The groups range from A-1, which consists of soils that have the highest bearing strength and are the best soils for subgrade foundation, to A-7, which consists of soils that have low strength when wet and are the poorest soils for subgrade.

The Unified system is used to classify soils according to their texture and plasticity and their performance as engineering construction material. Soils are grouped in 15 classes. There are eight classes of coarse grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. GP and GW are clean gravels, and GM and GC are gravels that include, respectively, an appreciable amount of nonplastic and plastic fines. SP and SW are clean sands. SM and SC are sands that include fines of silt and clay. ML and CL are silts and clays that have a low liquid limit, and MH and CH are silts and clays that have a high liquid limit. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML-CL.

Table 3 shows the estimated classification of all the soils in the survey area according to both systems of classification.

Estimated properties of soils

Estimates of soil properties significant in engineering are shown in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to differ significantly in soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Most soils in the survey area are deep enough over bedrock that bedrock does not affect their use. Bedrock is at a depth of 10 to 20 inches in the Rock Creek soils and at a depth of 30 to 40 inches in the Simcoe soils. Following are explanations of some of the columns in table 3.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in the standard terms used by the United States Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly"

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loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Permeability is the quality that enables a soil to transmit water and air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 3 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of a soil to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries or swells when it is wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Susceptibility to frost action is an important consideration in engineering, particularly in selecting sites for roads and airports. For frost action to occur, water must be in the soil and low temperatures must persist long enough for the water to freeze. The water may come from a high water table, may be capillary water or water held in voids, or may be water that infiltrates. Drainage to prevent the accumulation of water in soil pores helps to prevent accumulation of ice in the subgrade and subbase.

Risk of corrosion, as used in table 3, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion on uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material.

Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A rating of *low* indicates a low probability of soil-induced corrosion damage. A rating of *high* indicates a high probability of damage, so that protective measures for steel should be used to avoid or minimize damage.

Salinity refers to the amount of soluble salts in the soil (5). It is expressed as the electrical conductivity of the saturation extract, in mmhos. per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as construction material, and its corrosiveness to uncoated steel and concrete.

Engineering interpretations

The estimated interpretations in table 4 are based on the engineering properties of soils shown in table 3, on test data for nearby or adjoining soils, and on the experience of engineers and soil scientists with the soils of the Yakima Indian Reservation Irrigated Area. The ratings provided in table 4 summarize the limitation or suitability of the soils for all listed uses except for sewage lagoons, sanitary landfills, shallow excavations, and terraces and diversions. These columns in table 4 list those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are expressed as *slight*, *moderate*, and *severe*. *Slight* means that soil properties are generally favorable for the rated use or limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required.

Soil suitability is expressed as *good*, *fair*, and *poor*, which are, respectively, approximately parallel in meaning to the terms *slight*, *moderate*, and *severe*.

Following are explanations of some of the columns in table 4.

Topsoil is used in topdressing an area where vegetation is to be established and maintained. Characteristics that affect

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suitability are mainly the ease of working and spreading the soil material, as in preparing a seedbed; the natural fertility of the soil material or its response to growing plants when fertilizer is applied; and the absence of substances toxic to plants. Other characteristics that affect suitability are the texture of the soil material and its content of stone fragments. Also considered in the suitability rating is damage that can result at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 4 provide guidance about where to look for probable sources. A soil rated as a good or fair source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and they do not indicate the quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of the soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage. The ratings also reflect the relative ease of excavating the material at borrow areas.

Septic tank filter fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 1.5 to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Local roads and streets, as rated in table 4, have an all weather surface that is expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads and streets are

graded to shed water and have routine provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect the stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect the ease of excavation and amount of cut and fill needed to reach an even grade.

Dwellings, as rated in table 4, are no more than three stories high and are supported by foundation footings placed in undisturbed soil. Features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect the capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to water table; slope and stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

Reservoir areas hold water behind a dam or embankment. Soils suitable for reservoir areas have low seepage, which is related to permeability of the soil and depth to fractured or permeable bedrock or other permeable material.

Embankments and dikes require soil material that is

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resistant to seepage and piping and that has favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic materials in a soil material are among factors that are unfavorable.

Formation and Classification of the Soils

Soil is the product of soil-forming factors acting upon material deposited or accumulated by geological processes. The five factors of soil formation are climate, plant and animal life, relief, parent material, and time.

Factors of Soil Formation

Climate and living organisms, particularly vegetation, are the active forces of soil formation. Their effect on the parent material is modified by relief, by the length of time the factors have been active, and by the activities of man. The relative importance of each factor differs from place to place. In a few places, one factor dominates the properties of a soil, but normally the interaction of all five factors determines the kind of soil that forms.

Climate

The climate is arid in the Irrigated Area of the Yakima Indian Reservation. Summers are warm and dry, and winters are cool and moist. Most of the survey area has an annual

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precipitation of 6 to 9 inches. More detailed information on the climate is given in the section on climate under "General Nature of the Area." The main climatic factors that affect soil formation are precipitation and temperature. They affect soil formation through their influence on vegetation, weathering, and erosion.

The vegetation increases in density as the moisture available for growth increases. In the well-drained soils on uplands, the amount of water available to plants, as well as the depth to which the soils are leached, is affected by total precipitation, temperature, and to some extent, exposure. On the soils on the low-lying alluvial plains that have a high water table, vegetation grows more readily than on the soils on uplands.

Precipitation affects the rate of weathering because water

is the medium in which chemical reactions take place and is a source of hydrogen, the principal agent of weathering. The organic acids produced by decaying vegetation are another and, in most soils, more important source of hydrogen. If there is not enough water to carry away the end products of chemical reactions and if the depth of moisture penetration is limited, weathering is slowed and may be temporarily stopped.

Considering only natural precipitation in this arid area, the greatest hazard of water erosion is runoff from adjoining areas of higher elevations that receive larger amounts of precipitation. Erosion resulting from the application of irrigation water is in direct proportion to the degree of steepness of the topography.

Soil blowing is also a hazard in this survey area, especially on the sandy, droughty soils.

Warden soils have the low accumulation of organic matter typical of arid soils. Their subsurface horizon has weak, coarse, prismatic structure and high base saturation, and the soils are leached of calcium carbonate to a depth of about 22 inches. Hezel and Quincy soils are typical of the soils of the survey area that are sandy, lack soil structure, and are subject to soil blowing.

Plant and animal life

Organisms that affect the genesis of soils are the plants that grow on the soil and the microscopic plants and animals that live in the soil. These organisms affect the soil genesis through the addition of organic matter and nitrogen, the formation of organic acids, and the gains and losses in plant nutrients and changes in soil structure and soil porosity.

The Toppenish soils exemplify the effect of organisms in this survey area. The accumulation of organic matter in the surface layer is evident in the very dark color of that layer.

Relief

The relief or topography of the landform on which the soils formed influences the genesis of soil through its effect on drainage, erosion, plant cover, and soil temperature. The survey area consists of nearly level to steep soils on uplands and nearly level soils on bottom land. Most soils on uplands and some soils on bottom land are well drained, and in most places they are leached to a greater depth than the wetter soils. Some soils are wet as a result of a high water table or slow permeability.

Some soils on the bottom land are somewhat poorly drained and have characteristics associated with wetness. Such characteristics are the increase in the organic-matter content of the surface layer; the red, yellow, and brown mottles indicating oxidized forms of iron; and the blue or gray colors characteristic of reduced compounds. Toppenish, Track, and Zillah soils are examples of somewhat poorly drained soils on bottom land.

Many of the somewhat poorly drained soils on the bottom land and low terraces are affected by salts and alkali. Here, the water table is high or has been high in the past. Excessive amounts of salt and alkali accumulate on the surface, where ground water rises and evaporates. Among the soils in which this action occurs are Ahtanum, Fiander, Kittitas, Stanfield, and Umapine soils.

Parent material

Parent material is the unconsolidated material from which soils form. Its nature determines the mineralogical and chemical composition of the soil and, to a large extent, the rate at which the soil-forming processes take place.

The soils in this survey area are young, and profile formation has not progressed far enough to hide differences in parent material; therefore, parent material and the method of its deposition have been used as one means of identifying soils in the survey area.

Soils that formed in loess generally are silt loamy and are well drained. Ritzville and Shano are examples of such soils.

Soils that formed in eolian sand generally are loamy fine sands and are somewhat excessively drained. Quincy soil is an example.

Soils that formed in lacustrine sediments generally are silt loams, but in places they have layers of loamy fine sand or sandy loam. They are generally well drained. Warden soil is an example.

Soils that formed in material weathered from basalt are shallow and well drained. Rock Creek soil is an example.

Soils that formed in alluvium on bottom land vary in texture and drainage class from area to area. Esquatzel, Logy, Naches, Onyx, Weirman, and Zillah soils are in such areas.

Time

The length of time the parent material has been in place and exposed to climate and organisms is a most important factor in soil formation. The Quincy soil formed on a young land surface and has minimal profile development, whereas the Rock Creek soil formed on an old land surface and has strongly defined horizons.

As a result of farming in the survey area, man's influence on the genesis of the soil has been considerable. Activities causing significant changes in the soil started with clearing the land of its natural vegetation, followed by intensive irrigation farming and land leveling. Man's activities will continue to be highly significant as a soil-forming factor.

Soil Properties and Genetic Processes

No formal studies of the genesis of the soils in this survey area have been made. Nevertheless, by studying the typical profiles in the section "Descriptions of the Soils" and by applying knowledge obtained from research on similar soils elsewhere, much can be inferred about the soils.

Of particular importance are the kind and arrangement of horizons and the presence of mottles, a hardpan, alkali (exchangeable sodium), and calcium carbonate (lime) or other salts.

These properties and the processes responsible for them are defined in the paragraphs that follow.

A1 horizon.-In the well-drained and somewhat excessively drained soils in the survey area, the accumulation of organic matter, which forms an A1 horizon, has been small. Hezel and Quincy soils contain so little organic matter that they are not considered to have an A1 horizon. The reasons for this lack of organic matter are the small amount of organic residue as a result of low precipitation, the generally sparse vegetation, and the rapid decomposition of what residue is formed. With few exceptions, the organic-matter content of soils in the survey area that have not received additional moisture from runoff or underground sources ranges from less than 1 percent to less than 2 percent.

Onyx soils, though well drained, are more than 2 percent organic matter because their parent material was high in organic-matter content at the time it was deposited. The parent material was derived largely from the surface layer of higher lying soils. Little or no additional organic matter accumulated after deposition.

The A horizons of soils that formed under impeded drainage are about 2 to 5 percent organic matter. A more luxuriant vegetation, producing more organic residues, grew on these soils during formation than on other soils in the survey area.

B horizon.-In 16 of the soils in the survey area, a subsoil horizon has been altered sufficiently through soil-forming processes to be designated as a B horizon. In eight of these-the Logy, Ritzville, Ritzville gravelly subsoil variant, Shano, Toppenish, Track, Warden, and Yakima soils-changes have been small. They consist principally of structural development and brighter color. In the B horizon of Toppenish and Track soils the structure is moderate, and in the other six soils the structure is weak. The slightly brighter color of some of the B horizons as compared with horizons

above or below indicates that some iron oxides have been released during weathering.

The B horizon of the eight other soils-the Ashue, Fiander, Naches, Rock Creek, Simcoe, Wahtum, Wahtum dark variant, and White Swan-contains significantly more clay than their A horizon. Their parent material contained minerals that weathered to clay, and the material has been in place long enough for the clays to have accumulated in the subsoil.

The parent material of the soils that lack a B horizon is either resistant to weathering or has not been in place long enough for clay, a secondary mineral, to form from the primary minerals. In places, the clay has not been moved downward by percolating water; it remains flocculated because of the presence of salts, including lime. Apparently, there has been enough sodium in the parent material from which the Fiander, Wahtum, and White Swan soils formed to counteract the flocculating effects of the excessive amount of salts. Clay movement and deposition in the B horizon has taken place in these soils.

Lime.-Most of the soils in the survey area contain lime because their parent material was calcareous or because precipitation has been too low for lime that has been liberated from weathered minerals to be removed completely from the soil.

In the soil profile descriptions the symbol *ca* signifies a horizon having more lime than the parent material is presumed to have had. Thirteen of the soils that have such an horizon are the Ahtanum, Esquatzel, Fiander, Hezel, Kittitas, Naches, Quincy, Shano, Umapine, Wahtum, Wahtum dark variant, Warden, and White Swan soils.

Ten of the soils are nearly free of lime. The Ashue, Onyx, Weirman, Yakima, and Zillah soils formed in alluvium derived from surrounding upland soils from which most or all of the lime had been removed before redeposition. Yost soils formed in noncalcareous lake sediments. Rock Creek and Simcoe soils are shallow enough that lime in the parent material or liberated during weathering has been leached out by percolating water.

The *ca* horizon in Ritzville soils is typically at a depth of 30 to 43 inches. In most places in the survey area, however, these soils lack a *ca* horizon. The reason for this is not clear, but it may be that the loess parent material in this survey area was lower in carbonates than elsewhere. The fact that the *ca* horizon in Shano soils in this survey area is at a greater depth than in Shano soils outside of the survey area tends to support this. Ritzville and Shano soils are the only two soils in this survey area that formed primarily in loess.

Mottles and gleyed horizons.-Mottles occur in Fiander, Toppenish, Track, Umapine, Weirman, and Zillah soils. Yost soils are gleyed, or have dull colors, throughout. The reduction of ferric oxides to ferrous oxides in saturated soils is responsible for the mottled color pattern and dull colors. Reducing agents derived from decomposing organic matter are necessary.

Ferric oxides are generally a shade of yellow or red and are virtually insoluble. Ferrous compounds, which are colorless or have dull colors, are soluble. Consequently, ferrous compounds are mobile in the soil solution. They may move entirely out of a soil in drainage waters. They may move short distances where, if the moisture content decreases, they become oxidized to the ferric state and precipitate out of solution to form bright-colored mottles.

Some soils, such as Ahtanum, Kittitas, Stanfield, and Wahtum, have impeded drainage, but lack mottles or dull

colors. This is probably because the soils are not wet enough to provide an anaerobic environment, which is necessary for bacterial reduction of ferric iron to ferrous forms.

Lime-silica cemented hardpan.-Three soils in the survey area-Ahtanum, Stanfield, and Wahtum-have a hardpan cemented by lime and silica. The hardpan has formed where dissolved silica and calcium carbonates have concentrated and then precipitated out of solution. The parent material was probably high in volcanic glass at one time. Glass weathers rapidly, and soluble silicates are released.

Some question exists as to whether or not the pan in Stanfield and Wahtum soils is related to present-day soils. One theory is that the pan formed along the edges of old lakes before deposition of the material in which the present-day soils formed. Another is that the pan resulted from soil-forming processes acting on soil material that was subsequently eroded away. If the hardpan formed in another era, it undoubtedly has been thickened in places by the addition of lime and silica from present-day soil material.

Salts and alkali.-Soluble salts and alkali, or both, have accumulated in 10 of the soils in the survey area-the Ahtanum, Fiander, Kittitas, Stanfield, Toppenish, Track, Umapine, Wahtum, Wahtum dark variant, and White Swan soils. This accumulation is the result of ground water that contains excessive amounts of dissolved salts and alkali accumulating where the water rises near the surface and is either evaporated or transpired, leaving behind the salts and alkali. Two somewhat poorly drained soils-Yost and Zillah-do not contain excessive amounts of salts or alkali. Apparently the excess water in these soils was free or nearly free of salt or alkali, or the soils were flushed periodically by floodwaters from the nearby rivers. The Wahtum dark variant and White Swan soils are now considered well drained, but had impeded drainage at some time during their formation.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (6). Because this system is under continual study, readers interested in development of the current system should search the latest literature available (6).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. In table 5, the soil

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series represented in the Yakima Indian Reservation Irrigated Area are classified according to the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, both of which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is divided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu*, meaning water or wet, and *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons considered in making separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features considered are the self-mulching properties of clay, the soil temperature, the major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the dark-red and dark-brown colors associated with basic rocks. The names of great groups have three or four syllables and are made by

adding a prefix to the name of the suborder. An example is *Natraquolls* (*Natr*, meaning presence of significant amounts of exchangeable sodium or of magnesium and sodium, *aqu* for wetness or water, and *oll* from Mollisols).

SUBGROUP. Great groups are divided into subgroups. One represents the central, or typic, segment of the group. Others, called intergrades, have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those situations where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Natraquolls (a typical Natraquoll).

FAMILY. Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used in engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 5). An example is the fine-silty, mixed (calcareous), mesic family of Typic Natraquolls (*Natr*, meaning presence of significant amounts of exchangeable sodium or of magnesium and sodium, *aqu* for wetness or water, and *oll*, from Mollisols).

General Nature of the Area

This survey area supports a highly diversified irrigated agriculture. Among the commonly grown crops are asparagus,

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sweet corn, field corn, grapes, hay and pasture, hops, mint, potatoes, sugar beets, tree fruits, and truck crops. Within the survey area are undrained soils and saline-alkali soils that have not been reclaimed. These soils furnish grazing for livestock. Many areas are too steep or too gravelly, stony, or rocky to be cropped and are too small to be used for grazing. These areas furnish food and cover for some species of wildlife.

Farming enterprises support the business and industry of the area. Business, in turn, furnishes machinery, fuel and oil, fertilizer, insecticides, herbicides, and other items needed by an irrigated agriculture. A large cannery and a sugar factory are at Toppenish, and many packing sheds and cold storage plants for fruits and vegetables are within the area.

Water for irrigation is supplied through facilities provided by the Bureau of Indian Affairs and operated by several irrigation districts. It is diverted from the Yakima River and from Toppenish, Medicine, Simcoe, Satus, and Ahtanum Creeks. The source of these streams is in the snowfield of the Cascade Mountains.

Several lakes in the Yakima River system are used to store water for use when streamflow decreases in summer. No storage facilities are provided along the creeks, and water may be in short supply in summer.

Water is applied to the crops by corrugations, furrows, flooding, borders, and sprinklers. Most irrigated soils require artificial drainage. Careful control in applying irrigation water is needed on steep soils in order to prevent erosion.

CLIMATE

The climate in the survey area is characterized by warm, dry summers and cold, moist winters. Table 6 shows

temperature and precipitation data. Table 7 shows the probability of freezing temperatures in spring and fall, and table b shows the estimated growing degree-days above bases 40° and 30° F.

Among factors influencing the climate are topography, distance and direction from the ocean, prevailing westerly winds, and the path of weather systems crossing the Pacific Ocean. To the east and north, the Rocky Mountains shield this survey area from winter cold air masses moving south across Canada. Occasionally, air from over the interior of the continent spills over the Rockies or enters the inland basin through the north-south valleys that separate ranges in the southern part of British Columbia.

To the west, the Cascade Mountains form a barrier to the easterly movement of moist air from over the Pacific Ocean. Most of the air masses crossing this survey area have moved in from the ocean, where the surface is warmer in winter and cooler in summer than the land surface. This maritime air has a moderating influence throughout the year. The prevailing flow of air into the State in fall and winter is from the southwest. Orographic lifting and cooling of the moist air, at approximately 3° F. with each 1,000-foot increase in elevation as it rises along the western slope of the Cascade Mountains, results in heavy precipitation on the windward slope and near the crest.

Air descending along the eastern slope becomes warmer and drier, increasing 4° F. or more in temperature with each 1,000-foot drop. The cooling and warming of the air as it crosses the mountains results in warmer, drier air on the lee slope than at similar elevations on the windward slope. This produces a sharp reduction in precipitation as the elevation decreases in an easterly direction from the summit. For example, within a short distance of 10 miles, annual precipitation decreases from 90 inches or more at the crest of the

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Cascade Mountains to 48 inches at Bumping Lake at an elevation of 3,440 feet, and to 26 inches at Rimrock Dam at an elevation of 2,730 feet and 15 miles east of the summit. Within the next 15 miles it decreases to 8 inches at White Swan at an elevation of 974 feet. Approximately 50 percent of the precipitation falls in October through January, and 75 percent in October through March. Total rainfall for the two driest months is less than 5 percent of the annual total.

Average snowfall in the survey area ranges from 10 to 20 inches, and depths on the ground from 5 to 15 inches. Snow can be expected after the first of December. It remains on the ground for periods of a few days to 6 weeks between the middle of December and the last of February.

The prevailing direction of the wind is from the west, but the higher velocities are most frequently from the southwest. The average velocity ranges from 6 miles per hour in winter to 9 miles per hour in summer. The diurnal variation in wind is small in winter, but in summer an increase in velocity from the west occurs late in the afternoon.

Table 9 shows estimated evapotranspiration. Evapotranspiration is the combined process by which water is transferred from the earth's surface to the atmosphere by evaporation of liquid or solid water and by transpiration from plants. Potential evapotranspiration, or the maximum amount of moisture which, if available, could be removed under existing temperatures, is 25 to 30 inches. Assuming that soils have a water-storage capacity of 6 inches, computations are shown in table 9 of the actual evapotranspiration that occurs when precipitation and temperature are normal. Estimated annual amounts are 6 to 8 inches. Potential evapotranspiration exceeds actual evapotranspiration by approximately 20 inches.

Literature Cited

- (1) American Association of State Highway Officials. 1961. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 v., illus.
- (2) Portland Cement Association. 1962. PCA soil primer. 52 pp., illus.
- (3) Simonson, Roy W. 1962. Soil classification in the United States. Sci. 137: 1027-1034, illus.
- (4) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dept. Agr. Handb. No. 18, 503 pp., illus.

- (5) -1954. Diagnosis and improvement of saline and alkali soils. U.S. Dept. Agr. Handb. No. 60, 160 pp., illus.
- (6) - 1960. Soil classification, a comprehensive system, 7th approximation. 265 pp., illus. [Supplements issued in March 1967 and in September 1968]
- (7) Waterways Experiment Station, Corps of Engineers. 1953. The unified soil classification system. Tech. Memo 3-357, 2 v., illus. [Revised June 1957]

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called pods. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Ash, volcanic. Consists of small particles of solid or porous fragments of obsidian or pumice, which looks like coarse ashes, ejected in volcanic activity.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. The ratings are *low*, less than 3.75 inches; *moderate*, 3.75 to 5 inches; *moderately high*, 5 to 7.5 inches; *high*, more than 7.5 inches. Soils of low available water capacity require frequent but light irrigation, using a large head of irrigation water and short runs. Soils of high available water capacity can be irrigated less frequently with large quantities of water, using a smaller head and longer runs.

Blowout. An area from which soil material has been removed by wind. Such an area appears as a nearly barren, shallow depression with a flat or irregular floor consisting of a resistant layer, or accumulation of pebbly or wet soil lying just above a water table.

Bottom land. Low land formed by alluvial deposits along a stream or in a lake basin; a flood plain.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Crop rotation. The growing of different crops in recurring succession in the same field.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains

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cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are

Loose.-Noncoherent when dry or moist; does not hold together in a mass.

Friable.-When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.-When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.-When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.-When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.-When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.-When dry, breaks into powder or individual grains under very slight pressure.

Cemented.-*Hard* and brittle; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards. Drainage class (natural). Refers to the conditions of frequency and

duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

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Erosion hazard. Susceptibility to wind or water erosion. The terms used in this survey are *slight, moderate, severe, and very severe*. These terms are relative and apply only in relation to other soils of the Yakima Indian Reservation Irrigated Area.

Gravel. Rounded and semirounded fragments of rocks 1/8 inch to 3 inches in diameter. A single piece is a pebble. Gravelly soils contain 15 to 50 percent gravel, by volume.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. -The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. -The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. -The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. -The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. -Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Loess. Fine-grained soil, dominantly of silt-sized particles, that has been deposited by wind.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or by elevation of the lakebed.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance *few, common, and many*; size *fine, medium, and coarse*; and contrast *faint, distinct, and prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Perched water table. A layer of saturation in the soil, separated from the true ground water table and held above it by a layer of very slowly permeable or impervious material.

Permeability, soil. The quality of a soil that enables water and air to move through it. Terms used to describe permeability are

| | <i>Inches per hour</i> |
|------------------------|------------------------|
| Very slow ----- | Less than 0.06 |
| Slow ----- | 0.06 to 0.2 |
| Moderately slow ----- | 0.2 to 0.6 |
| Moderate ----- | 0.6 to 2.0 |
| Moderately rapid ----- | 2.0 to 6.0 |
| Rapid ----- | 6.0 to 20 |
| Very rapid ----- | More than 20 |

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

| <i>pH</i> | <i>pH</i> |
|--------------------------------|---------------------------------------|
| Extremely acid----Below 4.5 | Neutral -----6.6 to 7.3 |
| Very strongly acid-4.5 to 5.0 | Mildly alkaline ----- 7.4 to 7.8 |
| Strongly acid ----- 5.1 to 5.5 | Moderately alkaline---7.9 to 8.4 |
| Medium acid ----- 5.6 to 6.0 | Strongly alkaline ----- 8.5 to 9.0 |
| Slightly acid ----- 6.1 to 6.5 | Very strongly alkaline-9.1 and higher |

Runoff. The rate at which water is removed by flow over the surface of the soil. The rapidity of runoff and the amount of water removed are closely related to slope and are also affected by factors, such as texture, structure, and porosity of the surface soil; the vegetative covering; and the prevailing climate. Relative degrees of runoff are as follows:

Ponded. -None of the water added to the soil escapes as runoff.

Removal is by movement through the soil or by evaporation.

Very slow. -Surface water flows away so slowly that free water lies on the surface for long periods or enters immediately into the soil.

Very little of the water is removed by runoff.

Slow. -Surface water flows away so slowly that free water covers the soil for significant periods or enters the soil so rapidly that only a small amount is removed as runoff.

Medium. -Surface water flows away at such a rate that a moderate

proportion of the water enters the soil profile, and free water lies on the surface for only short periods. The loss of water over the surface does not reduce seriously the supply available for plants.

Rapid. - A large proportion of the water moves rapidly over the surface of the soil, and a small part moves through the soil profile.

Very rapid. - A very large part of the water moves rapidly over the surface of the soil, and a very small part goes through the profile.

Saline-alkali soil. A soil that contains a harmful concentration of salts and either a high degree of alkalinity or a large amount of exchangeable sodium, or both.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are - *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded

tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.